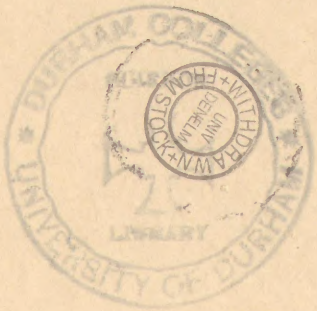
GEOLOGICAL SURVEY MEMOIRS
ENGLAND

WELLS AND SPRINGS OF WARWICKSHIRE

H.M. STATIONERY OFFICE
1928



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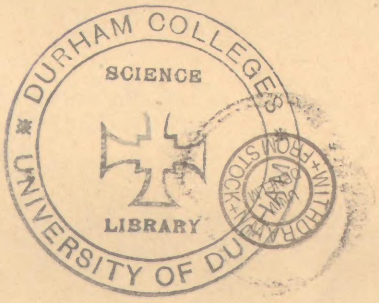
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MEMOIRS OF THE GEOLOGICAL SURVEY ENGLAND

Wells and Springs of Warwickshire

By

L. Richardson, F.R.S.E., F.G.S.

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PREFACE

This memoir, which is one of the series of volumes issued by the Geological Survey dealing with the underground sources of water in the counties of England, has been prepared by Mr. L. Richardson and edited for the press by Mr. R. W. Pocock.

The County of Warwickshire is unfavourably situated with respect to supplies of underground water, so that its great centres of industry and population secure most of their requirements from rivers near and far. Nevertheless the information here gathered together by the author will serve as a valuable guide for those who may wish to consider the possibilities of employing well-water.

The author has made personal investigation of the local sources of supply and a thorough examination of the literature of the subject. Thanks are due to all who have furnished particulars of wells, borings, springs, etc.; the author is especially indebted for information to Mr. F. W. Jones, Borough Surveyor, Stratford-on-Avon; Mr. J. J. Kennan, Borough Surveyor, Leamington Spa; Mr. R. C. Moon, Nuneaton; and Mr. J. F. Liverseege, City Analyst, Birmingham.

JOHN S. FLETT,
Director.

Geological Survey Office,
28, Jermyn Street,
London, S.W.1.
30*th April*, 1928.

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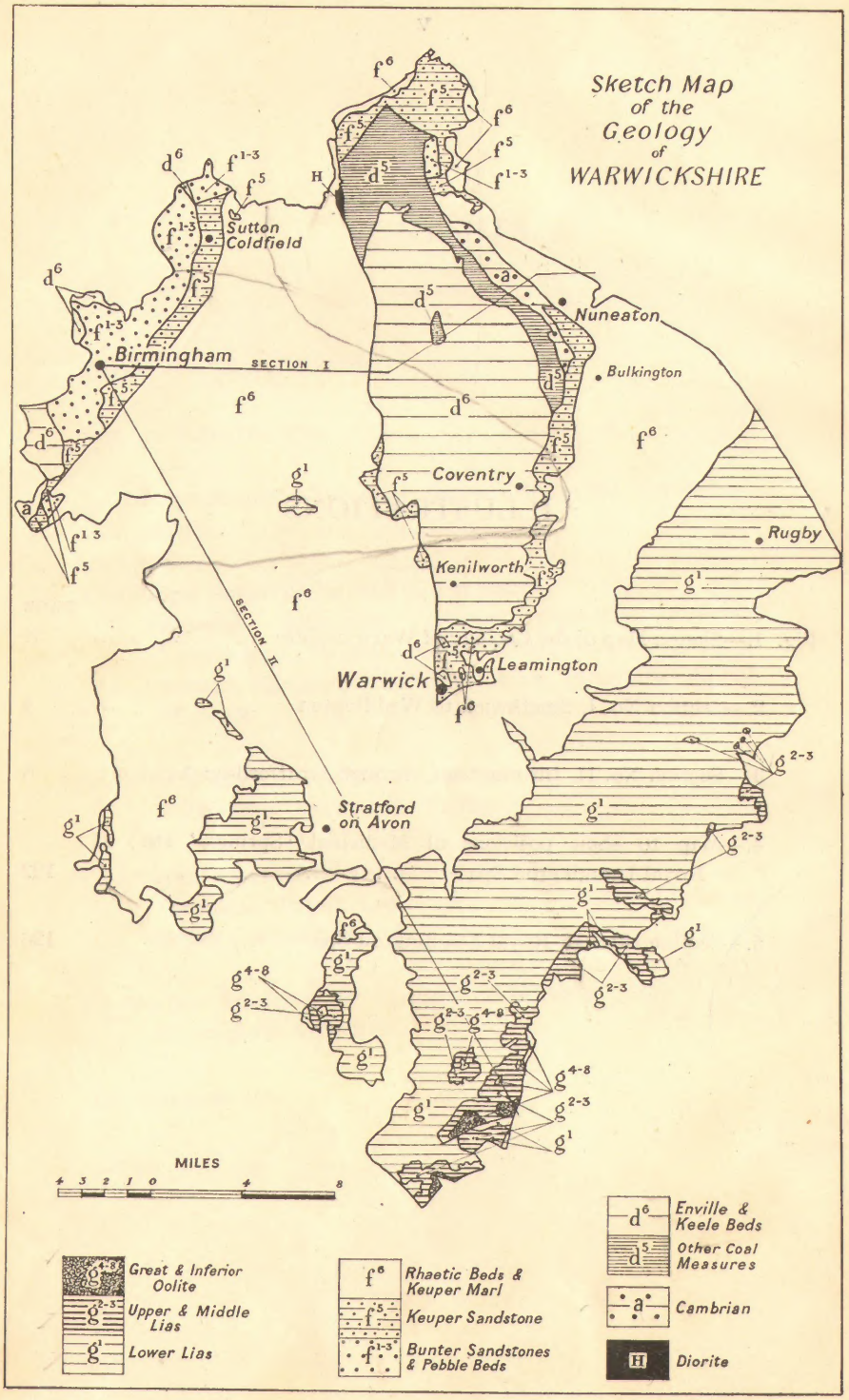

FIG. 1.—*Sketch-map of the Geology of Warwickshire.*

WELLS AND SPRINGS OF WARWICKSHIRE

I.—INTRODUCTION[1]

Warwickshire ranks twenty-third in size among the counties of England and Wales. Of its area of 902 square miles, 603 are in the basin of the River Avon ; 282 in that of the River Trent ; and 17 (in the extreme south-eastern portion of the county) in that of the River Thames. The condition of the rivers and streams as regards the effect of sewage-effluents upon their waters is very thoroughly investigated at regular intervals by the County Medical Officer of Health and his staff, and detailed quarterly reports and an annual summary are made.

The land-relief of the county, although for the most part undulating, is, on the whole, tame. The Warwickshire Coalfield, five miles north-westward of Coventry, attains an elevation of 600 feet above ordnance datum, but otherwise hills, worthy of the designation, occur only in the extreme south and south-east, and are Ebrington Hill, Edge Hill, the Burton Dassett Hills, and the outlying Shuckburgh and Napton Hills.

Omitting from consideration for the moment the Superficial Deposits, by far the greater part of the county is floored with impervious rocks—Lower Lias, Keuper Marl, and Coal Measure clays. Only comparatively small areas are floored with permeable rocks—principally Lower Keuper Sandstone and the sandstones and conglomerates among the Coal Measure clays. The Lower Keuper Sandstone has a wide subterranean extent, but its intake area is comparatively small. Water in the sandstone tapped by borings through impervious formations is usually hard, very frequently saline (Sodium Chloride), and the yield is very liable to fall off if a site is far distant from the intake owing to abstraction exceeding the natural recharge. The sandstones and conglomerates in the Coal Measures likewise have small intake areas. Deep down the closely-cemented nature of the majority of the beds renders them poor water-bearers and the water is carried mainly in fissures. At and near their outcrops, where decementation has taken place and where therefore they are good aquifers, the trouble is that soluble iron salts render the water in most cases unsuitable for public supplies.

Springs must be said to be numerous in the county, but the majority are from the Superficial Deposits and mostly small; there are few of sufficient volume to merit notice.

The county is, therefore, poorly off as regards water from underground sources. Consequently, recourse is had to surface sources —rivers. Nuneaton has made arrangements with Leicester to have a periodically-increasing (up to 1st January, 1936) supply

[1] The Birmingham area is discussed at p. 150.

from the latter town's Thornton reservoir; Coventry obtains the bulk of its supply from the Birmingham Corporation's Shustoke reservoir in which water from the River Bourne is stored; Rugby, the whole of its supply from the River Avon; Warwick, about five-sevenths of its supply from Drift resting on Keuper Marl, by means of 'adits'—trenches containing collecting-pipes and filled up with suitable material; and Stratford-on-Avon nearly two-thirds of its supply from an impounding reservoir at Snitterfield in which is collected water draining off Keuper Marl ground spread with Drift.

Greater or lesser portions of certain parishes, mostly on impervious beds, are supplied by undertakings with sources at a distance. Thus the East Worcestershire Waterworks Company supply Studley and Ipsley; the Birmingham Corporation's Waterworks a number in the Meriden Rural District and Solihull; the Rugby Urban District Council's Waterworks, Brownsover, Clifton-upon-Dunsmore, Hillmorton, and Newbold-on-Avon, in the Rugby Rural District; and the former North Warwickshire Water Company (purchased by the Coventry Town Council on September 21st, 1921), many in the Foleshill, Meriden, and Solihull Rural Districts, from wells in the Coalfield.

Table of Strata

In the following table the geological divisions and sub-divisions of the rocks occurring within the county are stated in descending sequence.

SUPERFICIAL DEPOSITS

Recent to Pleistocene :—		Ft.
Recent :	Alluvium	
Post-Glacial :	River-terraces	
Glacial :	Clays and loams; bedded sands and gravels; unbedded sands and gravels; boulder clays	up to 250

SOLID FORMATIONS

Jurassic :—			
Great Oolite :		Traces	
Fullers' Earth :		Limestone (Chipping Norton Limestone mainly)	
Inferior Oolite :		Limestone	
Lias :	Upper :	Clay	? up to 60
	Middle :	Marlstone	up to 30
		Sandy Beds	up to 120
	Lower :	Clay, almost entirely in the upper part, and limestones and clays or shales in alternating bands in the lower part ...	? up to 961
Triassic :—			
Rhaetic :	Upper :	White Lias	0 to 10
		Cotham Beds—principally clays or marls	10
	Lower :	Black Shales with *Pteria contorta* ...	up to ? 25

			Ft.
Keuper:	Keuper Marl:	Tea-green Marls	say 20
		Red marls	100 to 140
		Arden Sandstone (Upper Keuper Sandstone)	0 to 50
		Red marls with, locally, sandstone layers ("Passage Beds") in the bottom portion	800
	Lower Keuper Sandstone:	Sandstones, flaggy, and with some bands of marl in the upper part, more massive in the lower part with usually pebbly sandstones at the base	25 to 350
Bunter:	Upper:	U. Mottled Sandstone: Sandstones, soft, fine-grained	0 to 300
	Middle:	Pebble Beds: Sandstones with beds full of pebbles	0 to 250
(?Triassic) Hopwas Breccia		... ...	up to 100

Unconformity

CARBONIFEROUS[1]:—			
Upper Coal Measures:	Enville Group	... ...	3533 to 3693
	Keele Group	... ...	876 to 896
	Halesowen Sandstone Group	... ...	365 to 440
	Etruria Marl Group	... ...	80 to 150
Middle Coal Measures		... ...	464 to 594

Unconformity

CAMBRIAN:—		
Stockingford Shales:	Shales with intrusive igneous rocks of Ordovician age	3,000
Hartshill Quartzite:	Quartzitic Sandstones with ditto ...	900
PRE-CAMBRIAN:—		
Caldecote Volcanic Series:	Volcanic grits and tuffs with intrusive igneous rocks	

GEOLOGICAL FORMATIONS

As far as is known at present, deep down below Warwickshire is an old land surface composed of Archaean (Pre-Cambrian) and Cambrian rocks—probably mainly of the latter. In depressions in this surface the Coal Measures were accumulated. Folding, faulting, and denudation ensued, and one effect of these causes was the production of the Warwickshire Coalfield. The Warwickshire Coalfield—using this designation in a wide sense to include the productive Middle Coal Measures and non-productive Upper Coal Measures—is, in plan, roughly pear-shaped, with the narrow end pointing northward. From beneath the Coal Measures, towards the top of the 'pear', Archaean and Cambrian rocks emerge along the north-eastern margin from near Atherstone to near Bedworth (and have a N.W. to S.E. alignment), and Cambrian rocks only, along a part of the northern portion of the western margin at Dosthill—a couple of miles to the south of Tamworth.

[1] For detailed sequence *see* p. 8.

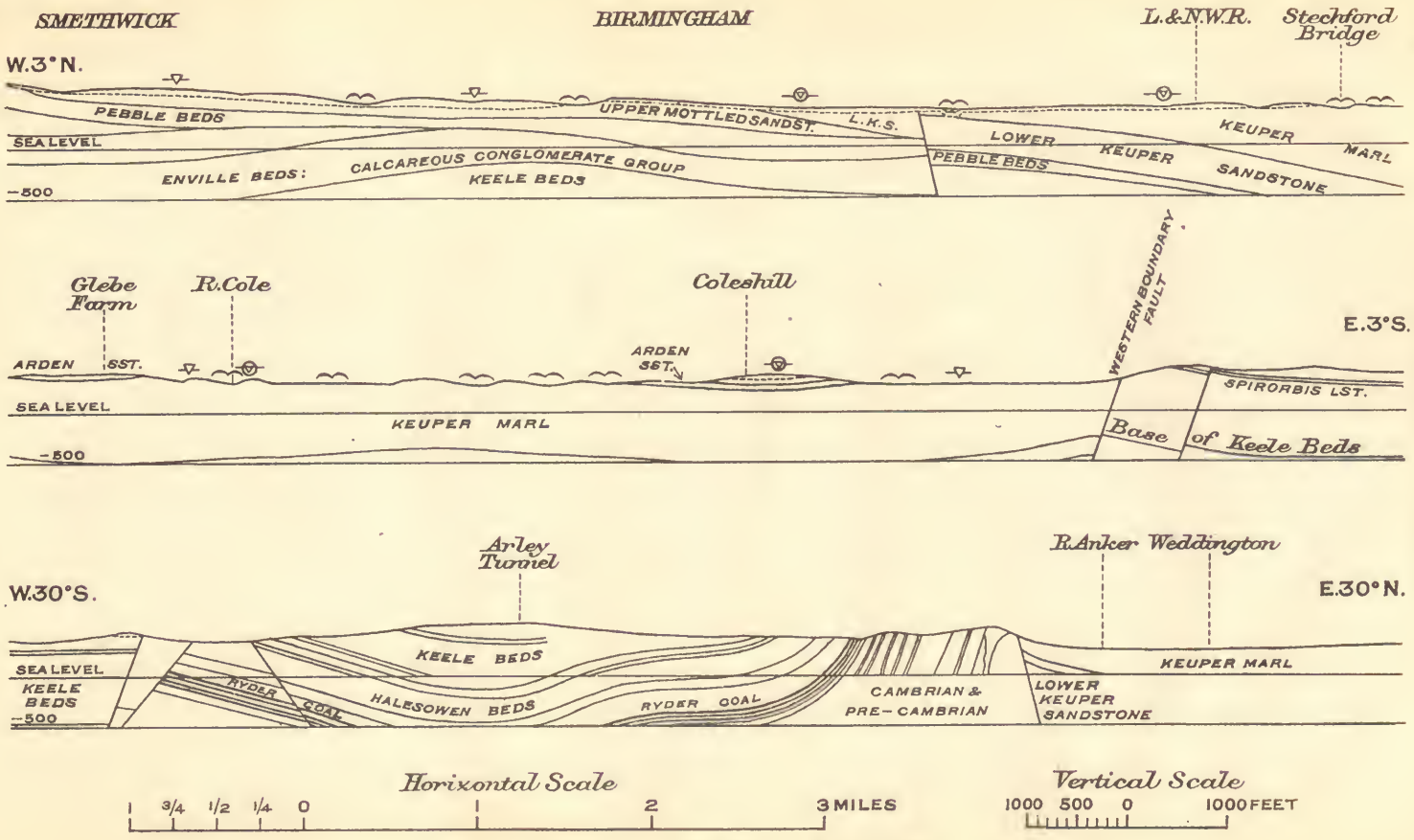

FIG. 2.—*Section No. I, Smethwick to Weddington.*

Archaean.—The Archaean rocks on the north-eastern margin of the Coalfield are the Caldecote Volcanic Series, consisting of tuffs and ashes. The tract in which they occur is about a mile and three-quarters long by, at the most, 300 yards wide; but the rocks are not of interest from the present standpoint.

Cambrian.—The rocks of this system comprise:—

(1) Quartzites—the Hartshill Quartzite, about 900 feet thick; and

(2) Shales—the Stockingford Shales, about 3,000 feet thick; with diorites, of Ordovician age, intrusive in both.

In the Atherstone-Bedworth tract both sub-divisions, (1) and (2), are present: the Hartshill Quartzite along a tract (scarred with many quarries) about 3 miles long by 500 yards wide; the Stockingford Shales along a tract about 9 miles long by (on an average) one mile wide. The Quartzites, with thin interstratified layers of shale, are broken up by innumerable little joints and fissures, which of course, carry a certain amount of water. Water from a well in them at the Midland Quarry, Nuneaton, of the quantity of about 40,000 gallons per day, was—until recently—pumped for the use of the Nuneaton Corporation, but probably the bulk of it was "quarry-water". The (Stockingford) shales, obviously, would not be the source of much water, although fissures in the associated igneous rocks carry some. Thus the Moor Wood Well (172 feet deep) in the shales and igneous rocks yields little water: so little indeed that the Atherstone Rural District Council is about to discontinue its use as the source of supply for a part of Hartshill.

In the Dosthill tract only the Shale division, with intrusive igneous rocks, occurs. Mr. George Barrow says[1]:—"The Cambrian shales yield little or no water, but the associated igneous rocks are traversed by joints and cracks which yield sufficient for small domestic supplies." Water is to be seen issuing from igneous rock above baked Cambrian shales in the lowest portion of the large Dosthill Quarry, and again in the cutting giving access to the quarry where the effluent water has made a deposit of sulphur derived from the decomposition of iron-pyrites.

Coal Measures.—The Coal Measures of the 'pear-shaped' Warwickshire Coalfield are roughly synclinally disposed, with the axis of the syncline pitching southward. The beds are locally faulted, particularly toward the apex of the 'pear', but, generally speaking, higher and higher Coal Measure subdivisions are encountered in a traverse from north to south, and the outcrops of the beds have a crescentic trend across the Coalfield.

[1] 'The Geology of the Country around Lichfield' (*Mem. Geol. Surv.*), 1919, p. 216.

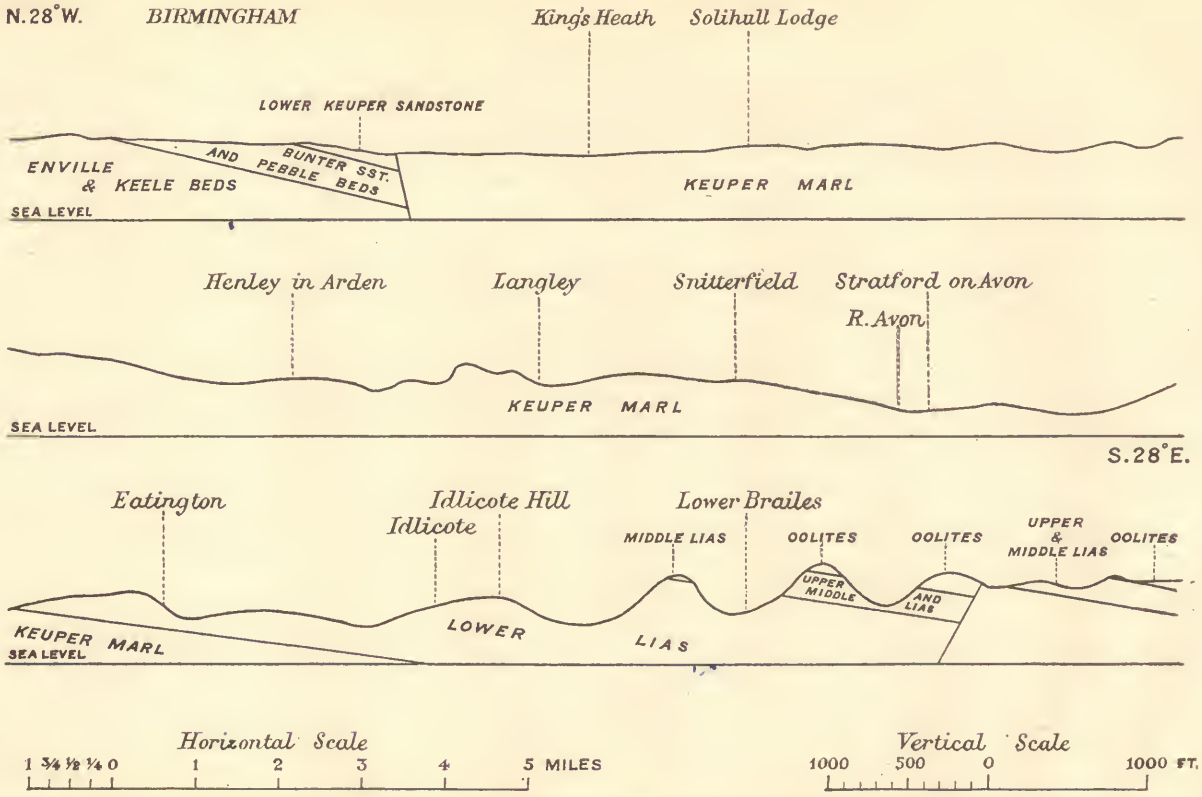

FIG. 3.—*Section No. II, Birmingham, through Stratford-on-Avon.*

The Coalfield (*sensu lato*) continues southward to the vicinities of Leamington and Warwick, where the Coal Measures (*s.l.*) disappear beneath the Trias. The Coal Measures of the south-eastern portion of the broad end of the 'pear' south of Coventry also disappear beneath the Trias; but those of the western portion, south of Dosthill, have been cut from off the 'pear' by the Western Boundary Fault, and, along with the overlying Trias, let down, so that Trias is in juxtaposition with Coal Measures along an approximately north and south line from near Dosthill to near Warwick. Dr. Walcot Gibson says[1]:—"North of Atherstone and along the whole length of the western margin of the coalfield the measures rise up sharply towards faults termed the Eastern and Western Boundary faults."

Coal Measures occur locally beneath the Trias to the east of the ridge of Cambrian rocks—over which they once arched—near Bedworth, for they (probably belonging to the Halesowen Group) have been proved at 98 feet below the surface in a recent boring, made by the Bulkington Urban District Council for water, at Bulkington. How far they extend to the south-eastward beneath the Trias and Lias of the Southam district is not known; but the distribution of the Middle Lias in the Edge Hill country, and of the succeeding Upper Lias and Oolites to the southward, is suggestive of a synclinal arrangement of these formations, and, if of these, probably of earlier formations. Southward of Leamington and Warwick Coal Measures certainly extend beneath the Trias, for the Enville Group has been proved by borings at 645 feet down at Moreton Morrell; at ? 390 feet at Bishops Tachbrook (Tachbrook Mallory); and at 332 feet at Heathcote. They are also present beneath the Trias to the west of the line of the Western Boundary Fault if that line be produced southward, for they (the Enville Group) have been proved by a boring at the Warwick Road Pumping Station of the Stratford-on-Avon Corporation Waterworks, beneath the Keuper rocks, at $635\frac{1}{2}$ feet down.

When the Enville Group of the Coal Measures is struck beneath the Trias to the southward of the visible coalfield, experience indicates that it is best to leave off boring for water: if an adequate supply has not been obtained from the Lower Keuper Sandstone it is unlikely that it will be augmented by continuing the boring into the Enville Group.

The water-bearing strata in the Coal Measures of the Warwickshire Coalfield will now be considered in ascending order.

The detailed succession of the Coal Measure beds in descending order is as follows:—

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[1] 'Coal in Great Britain,' 1920, p. 206.

? Upper Coal Measures.[1]	Approximate thicknesses in feet.
Enville Group :—	
Sandstones, red, with some beds of marl ...	220+
Marl with thin sandstone	130
Sandstone series (as at Love Lane, Kenilworth) with, at the base	80
Top Breccia Group : seen up to	8
Sandstones and marls, with, at the base ...	100
Bottom Breccia Group : seen up to	4
Marls and sandstones alternating	150
Sandstones, coarse, with conglomerates irregularly developed at various horizons passing to the west into breccias	50
Sandstones, thick, and marls	300
Tile Hill Marls	1450
Allesley Conglomerate : average	15
Red marls and sandstones	140
Corley Sandstones and Conglomerates	180—300
Red marls and sandstones	525
Astley Court Limestone	1
Red marls and sandstones	120
Exhall—Arley Conglomerate and Sandstones ...	60—? 100
	3533—3693
Upper Coal Measures.	
Keele Group :—	
Red marls	95
Maxstoke Limestone	2
Red marls and thin sandstones	430
Whitacre—Longford Limestone	2
Red marls and thin sandstones	225
Baxterley Limestone	2
Keele Sandstones with, at or near the base in the Nuneaton District, the 40-Feet Sandstone ...	120—140
	876—896
Halesowen Group :—	
Grey shales (mainly)	75—140
Index Limestone	up to 10
Grey marls (mainly)	157
Sandstones (mainly) :—	
Big Brown Sandstone	133
Marls locally	
100-Feet Sandstone	
	365—440
Etruria Marl Group :—	
Red marls with green grits (Espley Rocks) ...	80—150

[1] The particulars of the sequence down to the Allesley Conglomerate and the approximate thicknesses of the sub-divisions have been supplied by F. W. Shotton.

MIDDLE COAL MEASURES.

Measures (grey shales, sandstones, etc.) with, at or near the base, the 4-Feet Sandstone	120—150
4-Feet Coal	4
Measures	75
Thick Coal	20
Measures	50
7-Feet Coal	7
Measures	30
Double Coal	25
Measures	
Bench Coal	
Measures	133
Basal sandstone and conglomerate	0—100
	464—594

LOWER COAL MEASURES.—Absent.

The Middle Coal Measures are not productive of much water. The sandstone and conglomerate at the base of the Measures have been penetrated by the Ansley Hall Pumping Station well (basal Middle Coal Measures and Cambrian, 69 feet) between Ansley Hall Colliery and Moor Wood, from which water is supplied in bulk, by the Ansley Hall Coal and Iron Co., Ltd., to the Atherstone Rural District Council for the supply of parts of Ansley and Hartshill.

Near the 4-Feet Coal is a bed of sandstone that has been called the '4-Feet Sandstone'. It runs from Ansley to Bedworth, and yields a fair quantity of water when first pierced (as proved by shafts along its course such as Haunchwood); but the total quantity of water in it cannot be much, as the outcrop of the bed is so narrow. Little water was found in it at Charity Colliery, Bedworth.

At Binley Colliery (where the shaft went through 307 feet of Keuper Marl and Lower Keuper Sandstone; 46 feet of Etruria Marl; and into Middle Coal Measures) and at Exhall Colliery, salt water is pumped—from the latter colliery into the brook that flows through Wyken Pool.

The *Etruria Marl Group* (or Nuneaton Clay).—This group yields little or no water "as the Espley Rocks associated with them [The Etruria Marls] are firmly cemented by clay and carbonates at no great depth below the surface . . ."[1]

The *Halesowen Group*.—The sandstones (Haunchwood Sandstones) forming the lower part of the Halesowen Group constitute the most important aquifer in the Coal Measures and, in the Nuneaton district, the main mass, from 90 to 160 feet thick but on an average about 100 feet thick, is known in water-engineering circles as the '100-Feet Sandstone'. The outcrop of these sandstones runs from Kingsbury (where a large quantity of water was encountered during the sinking of the pit shaft), round by Islington,

[1] 'The Geology of the Country around Lichfield' (*Mem. Geol. Surv.*), 1919, p. 217.

Baxterley, Ansley Park, Haunchwood, Whittleford, Heath End, Clara Colliery (Griff), Charity Colliery, Bedworth, and Exhall Colliery, to the Hawkesbury Pumping Station of the Coventry Canal Co., where it disappears beneath the Lower Keuper Sandstone.

An important fault runs across the country between Bentley Park and Ansley to a point near Arley Station. By it the water in the northern part of the outcrop of the sandstones is completely cut off from that in the rocks in the southern part of the outcrop in the Nuneaton district.

The volume of water in the sandstones between Baxterley and Hawkesbury, according to information collected by Prof. Charles Lapworth about 1892, increases from north to south : from 400,000 gallons per day at Baxterley to 1,200,000 gallons per day at Griff, more at Exhall, and still more at Hawkesbury. Large quantities of water have been obtained from it at Baxterley ; Robinson's End Pumping Station ; Tunnel Pits, Haunchwood (about 1,000 gallons per minute in 1892) ; Whittleford Pumping Station ; Clara Pit, Griff (1,000 gallons per minute in 1892) ; Charity Colliery (recently closed) ; Exhall Pit ; and the Hawkesbury Pumping Station.

At the Robinson's End Pumping Station of the Nuneaton Corporation are two wells : the ' Old Well ' (396 feet deep, through the lower part of the Keele Group and into the Halesowen Group), which, however, has long been abandoned as a source of supply ; and the ' New Well ' (571 feet deep, through the lower part of the Keele Group and Halesowen Group—including the 100-Feet Sandstone). The average daily quantity of water now pumped is 80,000 gallons.

The shafts of the Clara and Marion Pits (sunk in 1892) passed through the 100- and 4-Feet Sandstones. During the period of sinking 1,000 to 1,200 gallons per minute were pumped from the 100-Feet Sandstone. When the 4-Feet Sandstone was reached 150 feet below, the total quantity of water increased to 1,300 gallons per minute, bringing the yield up to 1,812,000 gallons per day. The 4-Feet Sandstone was thus comparatively dry here.

At Bedworth the yield of the original borehole (? 230 feet) gradually diminished and the borehole had to be abandoned. The yield of a second borehole likewise failed and had to be abandoned. A supply was therefore obtained from the Newdigate Colliery Company, Ltd.,—from a spring in the shaft of the pit and a specially-made borehole.

The well at the Hawkesbury Pumping Station goes through 30 feet of Drift, 65 feet of Lower Keuper Sandstone, and for 25 feet into the 100-Feet Sandstone. The yield is said to be 1,500,000 gallons per day and the bulk of the water—which is very pure and leaves but little incrustation on the boiler—to come from the 100-Feet Sandstone. Where covered, the 100-Feet Sandstone carries water practically only in fissures owing to its being closely cemented with

interstitial clay and carbonates. The water therefore occurs in the form of a 'pound'. Owing to the nature of the rock the downward movement of water from the outcrop is very slow and therefore if abstraction from the 'pound' exceeds the natural recharge the yield gradually diminishes. Prof. Lapworth ascertained that the original great yield when the 100-Feet Sandstone was first pierced by a shaft or borehole was in no case maintained for more than two years and even then cases occurred where abstraction at one locality affected wells at others a considerable distance away: for example, pumping at Exhall affected the Hawkesbury well half a mile away.

Where uncovered, that is, along its outcrop, the 100-Feet Sandstone decomposes to a soft sandstone and is very absorptive. Unfortunately the decomposition has the effect of oxidising the iron salts in the rock and so impregnating and discolouring the water as to render it unsuitable for the purpose of a public supply. Also, if a well or bore is in or near the outcrop, the loose nature of the rock makes it ineffective as an eliminator of surface impurities that have got into the water.[1] Thus the waters of Griff and Exhall are strongly impregnated with iron, have a hardness of 28·42 degrees, and 35 solid impurities per 100,000.

The *Keele Group*.—This group contains water-bearing sandstones in its lower portion, the chief of which, in the Nuneaton district, has come to be known in water-engineering circles as the '40-Feet Sandstone'. The sandstones occur in faulted tracts near the northern extremity of the Coalfield, but their main outcrop runs from Gatley Common (east of Ansley), between Tower and North Lodge Farms (Seeswood Pool being on its western portion), Arbury Mill, Charity Spinney, Bedworth Heath (near the western margin of which it is contemplated sinking a well to augment the Bedworth supply), through Idle Lane to near Hawkesbury, where they disappear beneath the Trias.

The sandstones are closely cemented and therefore, deep down, the water is carried mainly in fissures. Where the rock is at the surface and has become decemented it is almost as permeable as the Bunter.

Wells or boreholes in or penetrating the Keele Sandstone are:—at the Polesworth Waterworks (Atherstone R.D.C., 60 feet deep; 5 ins. in diameter: supply parish of Polesworth); the Baxterley Well on Bentley Common (270 feet deep: bottom 3 feet in sandstone. Supplies furnished in bulk to the Tamworth and Atherstone R.D.C.'s); Birchley Heath Well (Atherstone R.D.C., 72 feet deep. Proved a failure owing to over-pumping and has been abandoned); Robinson's End Wells (Nuneaton T.C., were the first to prove that the 40-Feet Sandstone was water-bearing); and the Whittleford Well (Nuneaton T.C., 360 feet deep). The trial well (shaft and borehole, 142 feet) made at Hurley in 1892 by the Tamworth Rural District Council is in the sandstones; but while the yield was

considerable and the water still overflows from the bore—its use was vetoed by the Local Government Board owing to the possibility that the water might become contaminated by mining operations. The Bolehall boring (195 feet deep in Keele Beds) made by the Tamworth Council in 1875 yielded an insufficient quantity of water with a permanent hardness of 17·58 degrees. The bore has never been used and the water still out-flows.

At one time certainly the supplies from the 4-, 100-, and 40-Feet Sandstones in the Nuneaton district were pretty well exhausted; but as a number of the shafts, wells, and boreholes tapping these aquifers have been abandoned the beds will gradually become locally recharged. It has to be borne in mind, however, that the water contains iron to such an extent that it would be necessary to filter it before it could be used for a public supply.

The *Enville Group*.—In this group the aquifers are the Exhall-Arley Conglomerates and Sandstones, Corley Sandstones and Conglomerates and Kenilworth Sandstones and Breccias.

The Exhall Conglomerate supplies the Keresley well of the former North Warwickshire Water Company (purchased by the Coventry Corporation).

The main outcrop of the Corley Sandstones and Conglomerates extends from Corley (where in a lane-cutting and old quarry-face the beds are excellently exposed) south-east by south through Coventry —disappearing beneath the Trias a little south-east by south of the city. At Spon End, Coventry, are waterworks of the Coventry Corporation at which there are five boreholes in the Corley Beds. The area of the outcrop of the beds above the waterworks is about $4\frac{1}{2}$ square miles. The average daily quantity of water derived from the boreholes, which are artesian, is 958,524 gallons, so probably the aquifer is pretty well drained by these works. The Nuneaton Town Council sought power in 1919 to sink a well, close to the fault by which the succeeding Tile Hill Beds are let down against the Corley Beds, at a site a mile south of Corley. Coventry Town Council successfully opposed the scheme: the Council rightly feared that some of the 'head supplies' to their Spon End Works would be diminished.

A boring in the Tile Hill Beds in the Tile Hill goods-station yard, $693\frac{1}{2}$ feet deep, tapped water too hard for boiler-feed.

At Kenilworth there occur two beds of sandstone separated by marl. The upper bed, with one or more thin layers of breccia, and about 20 feet thick, is well exposed in Love Lane Quarry. A portion of the lower bed, which may total about 30 feet, was pierced between $8\frac{1}{4}$ and 24 feet down in No. 2 Borehole at the Kenilworth Urban District Council's Waterworks. The original source of supply to these Waterworks was an 'adit,' thought to be about 300 feet long, roughly parallel to the Finham Brook, and

said to be excavated in sandstone and to rest on a bed of clay overlying the lower sandstone. This adit, however, was filled up in 1914, and the present supply is obtained from three boreholes, respectively, 226½, 230, and 267½ feet deep. The average daily quantity of water derived is 157,000 gallons and the bulk of it is said to come from between 190 and 220 feet down. The rest-level in all three boreholes is at about 20 feet below the surface.

Similar twin sandstones with intervening marl are displayed in the cutting on the Leamington road at Stoneleigh Hill, Stoneleigh.

Above the Kenilworth Sandstones and Breccias come marls followed by the Whitemoor Sandstone which is well seen in the pit of the Whitemoor Brick Works close to Kenilworth Station. This Whitemoor Sandstone has a very slight southward dip, and keeps very near the surface between Kenilworth and Warwick. Eastward, however, this sandstone and its associated beds are probably locally flexed with the development of a synclinal area to the south-eastward so that in that direction higher beds succeed. Between Warwick and Leamington the beds disappear beneath the Trias, but they are probably flexed so that their prevalent dip is not maintained and they are brought locally nearer to the surface than might be expected : as already mentioned they have been proved beneath the Keuper Sandstone at Stratford-on-Avon, Alveston Hill, Heathcote, Tachbrook Mallory, and Moreton Morrell. Until recently it was not suspected that the Enville Beds (*olim* Permian) occurred immediately beneath the Lower Keuper Sandstone away from the immediate vicinity of the southern portion of the Warwickshire Coalfield and the tendency of drillers has been to assume that all sandstone met with below the Keuper Marl was Keuper Sandstone.

A boring made in 1852 in The Union grounds at Warwick was carried to a depth of 700 feet in Enville Beds, but it had to be abandoned for it tapped little water and such as it did was saline.

In future borings it is to be hoped that drillers will distinguish between Lower-Keuper and Enville-Group sandstone : the former is generally grey ; the latter reddish. Enville-Group marls—when fresh—are generally chocolate-coloured. Also, it will probably be found that whereas cores of Keuper Sandstone break horizontally, those of Enville-Group beds break obliquely, owing to the dip of the beds of the former formation being practically nil, but of the latter, pronounced.

Where they occur at or near the surface the Enville-Group sandstones furnish useful supplies to private wells ; but where they occur deep down—as in the Warwick Road boring, Stratford-on-Avon—they appear to possess the usual qualities of Warwickshire Coal Measure sandstones and, as a rule, to be productive of less water than might be desired.

Trias.—The Trias comprises :—

	Ft.
Rhaetic	up to 45
Keuper Marl	up to 1100
Lower Keuper Sandstone	25 to 350
Upper Mottled Sandstone	0 to 200
Pebble Beds	0 to 250
Lower Mottled Sandstone	Absent

Pebble Beds.—The Pebble Beds occur at the surface to the west of the Birmingham Fault—from the vicinity of Sutton Coldfield south-westward to the Bourn Brook; but to the east and south-eastward (as shown in the section on the Geological Survey Map, New Series, Sheet 168) rapidly thin out. Apart from their occurrence in this Sutton Coldfield—Birmingham area, and in an area of about one square mile near Polesworth, the Pebble Beds are absent from the county. In the small area near Polesworth, in which the Bunter is best described as 'Bunter Sandstone with Pebble Beds', is the Warton Pumping Station of the Atherstone Rural District Council from which are supplied Atherstone and parts of the parishes of Grendon, Hartshill, Mancetter, Merevale, Oldbury, and Baddesley. At the Pumping Station are two boreholes: No. 1.—300 feet deep (20 in. in diameter), through 64 feet of Lower Keuper Sandstone and for 236 feet into the Bunter; and No. 2.—304 feet deep (22½ in. in diameter), through 60 feet of Lower Keuper Sandstone and for 244 feet into the Bunter. The average daily quantity of water derived is 150,000 gallons.

Upper Mottled Sandstone.—This subdivision is present in the county only to the west of the Birmingham Fault—from Boldmere, near Sutton Coldfield, to the vicinity of the Bourn Brook. In the neighbourhood of the fault at Birmingham it is overlapped by the Lower Keuper Sandstone.

Lower Keuper Sandstone.—The Lower Keuper Sandstone has a wide subterranean extent in the county, everywhere underlying the Keuper Marl. Outside the Birmingham area it may be assumed that, as a rule, it rests on Coal Measures (i.e., including the Enville Group).

The Lower Keuper Sandstone occurs at the surface—except, of course, where covered with Drift—along a tract west of the Birmingham Fault from Sutton Coldfield southward nearly to the Lickey Hills; emerges from beneath the great spread of Upper Keuper Marl, at places, such as at Meriden, Berkswell, etc., adjacent to the western side of the Western Boundary Fault of the Warwickshire Coalfields; crops out around the northern end of the Coalfield in the vicinity of Seckington, Shuttington and Warton; to the south-west of Atherstone; and continuously *via* Wyken, Stoke, Whitley, Baginton, Royal Leamington Spa, to Warwick, where—owing to the Western Boundary Fault—it comes into juxtaposition with the Keuper Marl. From the vicinity of Tamworth to Nuneaton the boundary-line between the Sandstone, where it emerges,

and the older rocks is the Eastern Boundary Fault of the Coalfield ; but from Nuneaton to Warwick it is, as a rule, where the Sandstone ' peters out ' on the Enville Beds, which it succeeds, but of course, unconformably.

The Lower Keuper Sandstone is one of the best formations for water, being, especially where it occurs at or near the surface, easily permeable so that rain sinks into it and percolation is at a high rate. The lower part is a better aquifer than the upper, being coarser grained.

Where the Sandstone crops out, or where it occurs beneath a covering of Keuper Marl of inconsiderable thickness, the water in it is usually ' fresh '—that is, non-saline ; but it is generally on the hard side. Supplies are obtained from it :—(?) at the Woodloes Pumping Station of the Warwick Corporation's Waterworks ; the Warwick Laundry ; Emscote Mills, Warwick ; Royal Leamington Spa Corporation's Campion Terrace and Lillington Pumping Stations ; Whitley Pumping Station of the Coventry Corporation's Waterworks (where the yield of the well, 960,000 gallons per day, is more than might have been expected, but several streams traverse the outcrop of the sandstone in the vicinity of the well and the well also pierces—to a depth of 194 feet—the Corley Conglomerate in the Enville Group) ; and at the Hawkesbury Pumping Station of the Coventry Canal Company, where the yield of the well is said to be about 1,500,000 gallons per day, but the bulk of this water comes from the immediately underlying 100-Feet Sandstone of the Halesowen Group. The yield of the White Stone (Trial) Well, near Nuneaton (40,000 gallons per day) was less than was expected and less than the Hinckley Corporation required and the well was therefore abandoned. A well near Warton, made for the Atherstone Rural District Council, tapped such extremely hard (mostly permanent) water that it had to be abandoned ; but the well from which Seckington is supplied yields satisfactory water.

The water in the Lower Keuper Sandstone where covered by a considerable thickness of impermeable beds varies much in quantity and quality from place to place. It is usually hard and locally so highly charged with common salt as to be useless for ordinary drinking purposes.

Borings at Stratford-on-Avon (at the Brewery and at the Warwick Road and Alveston Hill Pumping Stations of the Corporation) ; Claverdon ; Hatton (County Mental Hospital) ; Heathcote, near Warwick ; Moreton Morrell ; and Moreton Paddox, tapped supplies satisfactory as regards quantity and quality. When the Brewery boring at Stratford-on-Avon was first made there was an artesian head sufficient to afford a natural flow of 1,800 gallons per hour at 50 feet above the surface,[1] but it has since lessened ; at present the Warwick Road borehole overflows ; and for some time so did that

[1] Brown, H. T., *Geol. Mag.*, 1896, p. 54.

at Alveston Hill, but now the water has to be pumped from it. It would appear then that after a time the artesian head of water rising through the boreholes in this district from the Lower Keuper Sandstone lessens, doubtless owing to the outcrop of the Sandstone being so far distant and the quantity of water pumped exceeding the natural recharge of the stratum. No doubt the Claverdon borehole could be overpumped. A point that requires watching in these deep bores when the artesian head gradually diminishes or the rest-level falls is whether the sodium chloride content of the water is on the increase : if it is, the fact suggests over-pumping and the drawing on lower and more ' stagnant strata ' of water.

The borings at Tachbrook Mallory ; Leamington Spa Steam Laundry ; Barby Road, Rugby ; and Moor Farm, near Tamworth ; struck salt-water, and probably others have done so. Salt-water is also pumped from certain pits that penetrate Lower Keuper Sandstone in the Coventry district. The Leamington Medicinal Waters come from this sandstone.

The occurrence of salt water in the Lower Keuper Sandstone is very sporadic : one would expect ' stagnant ' water shut down under impervious beds to be rich in Sodium Chloride, but there is the fact that at many localities it is not so.

Numerous boreholes have had to be abandoned because the water was too hard for domestic purposes.

Keuper Marl.—The Keuper Marl floors a very large portion of the county and has a wide subterranean extent : it probably underlies the whole of the Liassic tract in the eastern, south-eastern, and southern portions of the county.

In the Marl, at from 120 to 160 feet below its upper limit, is very generally present a sandstone-formation known as the ' Arden Sandstone '. This Arden Sandstone (or ' Upper Keuper Sandstone ' as it has been called by some authors) appears to attain a maximum thickness of 50 feet, but on an average is 25 feet thick, and, locally, is represented merely by bits of blue shale. Owing to the flexings to which the Keuper Marl has been subjected, and in which, of course, the Arden Sandstone has been involved, the Sandstone—as is well shown on a map by Dr. C. A. Matley (*Quart. Journ. Geol. Soc.*, vol. lxviii, 1912, pl. xviii) crops out at many places. It is an important source of water for small requirements, and many springs, such as The Dingle and Slad Springs in Great Alne parish, issue therefrom.

Sandstone beds are also of usual occurrence in the basal portion of the Marl. In the vicinity of Orton-on-the-Hill in Leicestershire, but close to the Warwickshire boundary north of Atherstone, they are numerous, well developed and separated by marl deposits. They vary much, however, in number and thickness from place to place, and, locally, may be absent. For these basal sandstones and marls it is often convenient to use the term ' Passage Beds '.

The upper portion of the Marl (as seen by the section in the pit of Alfred Espley's Brickworks, Ltd., Stratford-on-Avon), and the lowest 35 feet or so (as proved by the borings at the Warwick Road Pumping Station of the Stratford-on-Avon Corporation, and the County Mental Hospital, Hatton, and the section in the pit of the Leamington and Lillington Brickyard Co., Ltd., Royal Leamington Spa) are devoid of gypsum; but the median portion is very liberally veined and zoned with fibrous gypsum and alabaster. The salt-beds of Droitwich occur in the Keuper Marl; but in Warwickshire, so far as the writer is aware, no salt has been detected. No information has been obtained that any private wells in the Marl yield brackish water. In the Warwick Road boring, Stratford-on-Avon, no water was encountered in the marls: they were waterless. Speaking generally, the Marl constitutes an impervious formation: such downward movement of water through it as there may be must be extremely slow. For some distance down from the surface, however, the beds are traversed by innumerable little cracks and in these water collects and may be tapped by wells of adequate diameter, but small-diameter boreholes are seldom successful. Many isolated houses have to depend for their supplies on wells sunk in the marl and from enquiries it is understood that there is no general shortage—not even in dry periods. In many cases, however, the wells first penetrate Superficial Deposits (sand and gravel), and doubtless in such cases much of the supply is derived therefrom.

The Alcester Waterworks derives the bulk of its supply from (1) a well, and (2) a borehole in the Keuper Marl; but otherwise no public or private supply of any note derives water therefrom.

Rhaetic.—The Rhaetic Series comes between the Keuper Marl and the Lower Lias, and crops out at or near the top of a well marked escarpment from the vicinity of Loxley, *via* Moreton Morrell, Chesterton, and Ufton, to near Long Itchington. In the extreme north-eastern portion of the county, however, the usual escarpment is hidden beneath a thick accumulation of Drift.

The Series is divisible into :—

Langport Beds.	White Lias.—Limestones	0—10 ft.
Cotham Beds.	Marl principally, of a greenish-grey tint	10 ft.
Westbury Beds.	Black shales principally	up to ? 25ft.

The White Lias (contemporaneous with and similar to the White Lias of Somerset) is the only division of interest from the present standpoint. Owing to the slight dip of the beds and to shallow valleys excavated by streams, the White Lias is displayed at the surface, or occurs not far below a covering of Lower Lias, at many places in the rear of its main escarpment. It is exposed beneath the Lower Lias at the Newbold Limeworks; between Red Hill and Ettington Station; at Fosse Farm (two and a half miles west of Kineton); to the north-east of Compton Verney Park; in the vicinity

of Chesterton; at Stoney Thorpe, near Southam; and in the railway-cuttings at Harbury and Church Lawford.

The White Lias consists of limestones with occasional thin partings of clay or shale. The limestones are much fissured, and the fissures naturally carry water: Holywell Spring, Southam, issues therefrom, and the Southam-Supply well a little to the north of it taps water therein (see remarks under Lower Lias). The water like that of the Somerset White Lias, is hard, and at places there are 'petrifying' springs.

Jurassic.

Lower Lias.—The Lower Lias forms a broad belt of ground in the eastern, south-eastern, and southern portions of the county, in which are situate Rugby, Southam, and Kineton.

The formation is separable into two portions:—

(1) Clay, almost entirely; and
(2) Limestones and clays (or shales) in alternating layers such as are excellently displayed in vast quarries attached to the cement-works at Rugby, Stockton, and Harbury.

The Lower Lias is well known as a bad formation in which to seek water: attempts made in this county have had results very similar to those obtained in other counties. Such little water as has been encountered in the limestones of the lower division, either in borings or issuing as springs, is hard; and in the clays of the upper division it is hard, usually saline,[1] and locally impregnated with sulphuretted hydrogen. Saline and Saline-Sulphur Waters encountered in the wells at Bishopton (Stratford-on-Avon) and Willoughby led to the establishing of Spas which enjoyed a short-lived notoriety. Medicinal Waters have been noted at the following localities:—

Parish	Name or Site	General Character
Clifton-on-Dunsmore	Lodge Farm Boring	Sulphur (?-Saline)
Kings Newnham	'The Wells' (spring)	
Willoughby	Willoughby Lodge Spa (well)	Sulphur-Saline
	Willoughby New Sulphureous and Saline Baths (well)	Ditto
Southam	'Salt Spring,' Southam Holt	Saline
Fenny Compton	Railway-cutting near Station	Do.
Burton Dassett	Manor House Farm (pond)	Do.
Brailes	On Tusbrook Farm	Chalybeate
Halford	Near 'The Lion' (well: 55 ft.)	Saline
Oxhill	Council Well	Do.
Watcote	Kirby Farm Boring (200 ft.)	Do.
Stratford-on-Avon	Royal Victoria Spa, Bishopton	Sulphur-Saline
Binton	Binton Hill Boring (150 ft.)	Saline

[1] It may be as well to state that cases are known in which water directly collected from a new well (or borehole) that is very hard and saline has decreased considerably in hardness and salinity after much water has been pumped to waste and that in the well (or borehole) has become clear.

From the preceding particulars it will be readily understood that towns, villages, and even isolated dwellings on the Lower Lias are likely to be badly off for water if dependent on supplies derived from the formation. Rugby has had to make use of River-Avon water after filtration and chlorination. Southam was dependent on mostly unsatisfactory private wells until 1925 in which year a Waterworks was completed. The source of supply is a well (34 feet deep and 6 feet in diameter) a little to the north of Holy Well—a well-known spring. The well appears to pierce the Rhaetic White Lias from which the water comes. During a 23 days' pumping-test (from 27th June—19th July, 1914) the minimum yield was 106,000 gallons per day and the maximum 215,000 gallons per day. According to the *Sixth Report* (1874) *Rivers Pollution Commission*, p. 127, the total hardness of the Holy Well water is 42·8 degrees (permanent hardness, 18·4 degrees). Kineton is supplied from a spring (King John's Well) and ' adit ' fed with water from limestone-bands in the Lower Lias clay, but the quantity of water is very small and inadequate for requirements. Combrook and Loxley villages have piped supplies from small springs of like origin. In the Brailes Rural District a few useful springs issue from the outcrops of limestone-bands, for example, at Pillerton Hersey.

It is, therefore, fortunate that considerable portions of the surface of the Lower Lias are covered with Superficial Deposits. This is particularly the case in the vicinity of, and northward of, Rugby, where there is a wide spread of Boulder Clay with associated sand and gravel. Southward the Boulder Clay element lessens in evidence, and more or less loose, more sporadically distributed, sands and gravel predominate (see *Superficial Deposits*).

Middle Lias.—The Middle Lias consists of Sandy Beds (say up to 120 feet) succeeded by ferruginous Marlstone (up to 30 feet), which, in the Banbury district, is the ' Banbury Ironstone '.

In Warwickshire, the Middle Lias occurs only in the south-eastern and eastern portions of the county—in parts of the Southam, Farnborough, and Brailes Rural Districts. Numerous springs issue at or near the base of the Sandy Beds, from which they are thrown out by the underlying Lower Lias clay. The springs, however, are small ; in the main Edge-Hill mass the dip of the rocks is away from the vale, so that the water that falls as rain travels inwards. There are no good springs from the formation in this county running to waste.

Water from the Middle Lias is frequently irony, but apparently, not any of that used for the purpose of supplies is so. At one time a somewhat famous chalybeate ' Medicinal Spring ' was Lord Capell's at Ilmington.

Villages supplied in part or whole by piped supplies from Middle Lias springs are :—Ilmington (from Wedgnock Spring), Wichford, Little Compton, Cherington, Lower and Upper Brailes, the Tysoes.

Radway, Warmington, Knightcote and Northend, Fenny Compton, Avon Dassett, Priors Hardwick, Priors Marston, Lower Shuckburgh, and Napton-on-the-Hill.

Upper Lias.—The Upper Lias is all clay and throws out water from the base of the succeeding Oolites.

Oolites.—These rocks occur in very small tracts : they cap Ebrington and Brailes Hills, and elevated ground in the vicinity of Little Compton. Small springs from them are used to supply parts of the villages of Upper Brailes, Little Compton, and Long Compton.

Superficial Deposits.—Superficial Deposits are distributed extensively over the surface of the 'solid' rocks in Warwickshire. They consist of Drift—Boulder Clay, sandy clay, gravel and sand, and, mainly margining the rivers and more important brooks, Alluvium. The Drift varies considerably in thickness : at some places it fills up deep hollows in the surface of the 'solid' rocks ; at others, forms banks ; and, at yet others, over very extensive tracts, it is thinly distributed.

The Boulder Clay, with its associated sand and gravel, is most in evidence east of the northern part of the Warwickshire Coalfield : a boring at Cloudesley Farm, Withybrook, proved a thickness of 201 feet before entering (for 12 feet) the Keuper Marl, but the water obtained is said to be poor and to smell 'gassy'. The Monks Kirby Rural District is wholly on Boulder Clay, and is dependent on wells from 15 to 60 feet deep, many of which tap water in the sand-beds that are associated with the Boulder Clay. Supplies are generally adequate, and relatively few wells run dry during or following a drought. The water, however, is hard—both permanent and temporary hardness.

The Boulder Clay also forms considerable spreads in the vicinity of Shirley—south-eastward of Birmingham, and along the western portion of the city ; but the surface of the Coal Measures in the northern portion of the intervening Warwickshire Coalfields is comparatively free from coverings of Boulder Clay, etc. Mr. George Barrow says[1] : " In the Keuper Marl area, between the Hints Fault and the Tame, many springs issue from the base of the overlying Drift, some capable of supplying a house, but the majority small and dry during long droughts." Springs issuing from Drift supply Middleton village. Southward the Boulder Clay element lessens in evidence and more or less loose sands and gravels constitute the predominant Superficial Deposit.

The sand and gravel deposits readily absorb water, but, of course, the quantity a given spread contains, depends on the extent, thickness, and position occupied by the deposit. The occurrence of patches of Superficial Deposits on clay or clayey formations such as the Keuper Marl and particularly the Lower Lias, has played an important part in determining the selection of sites for villages

[1] 'Lichfield Memoir,' pp. 220, 221.

and isolated dwellings. Warwick obtains the bulk of its supply from sand and gravel resting on Keuper Marl by means of collecting trenches ('adits') at Haseley; and Stratford-on-Avon the greater part of its supply from sand and gravel resting on Keuper Marl at Snitterfield. The supply for Henley-in-Arden is derived from springs from Drift on Marl at Forde Hall and Liveridge Hill; and that for Ellenhall from a spring of like origin. Among villages having piped supplies from Drift on Keuper Marl are Snitterfield and Sherborne. One of the three sources of supply of the Alcester Waterworks is a spring from the Arrow-side river-terrace in a field east of the southern end of the railway bridge over the Arrow. Brandon village is in part supplied by a private undertaking from a well in gravel of the Avon river-terrace. Mr. George Barrow says[1]: —"The water in the Tame gravels is distinctly foul and smells badly in hot, dry weather when the river is low," and (*idem*, p. 224):—"The result of the tests of water made by the Tamworth Board was summarised by Mr. Martin in the Report of the British Association for 1887, p. 366. It was found that the water from the river-gravels east of Tamworth in the Anker valley contained from 38·47 grains of solids per gallon, and a permanent hardness of 14·8 to 16, a higher degree than would have been expected from such deposits." The water for the original piped service to Rugby was obtained from sand and gravel resting on Lower Lias, by means of deep collecting-drains, in the vicinity of the Water Tower close to the Barby Road; but after some years the supply diminished, and this source of supply was abandoned. In the Brailes Rural District supplies are obtained from sand and gravel resting on Lower Lias for Great Wolford, Idlicote, and Stretton-on-Fosse.

River Systems

The river-system of Warwickshire is a simple one. The greater part, 603 square miles, is drained by the Avon—a tributary of the Severn. The lesser part, 282 square miles, drains by the Tame into the Trent; while a small and inconsiderable area, 17 square miles, lies in the basin of the Thames.

SEVERN BASIN

River Avon.—The Upper, Lesser, Warwick, or Stratford Avon rises a little south-westward of the 'Fitzgerald Arms,' Naseby, Northamptonshire,[2] and enters Warwickshire at Dow Bridge, which carries the Watling Street over it about three miles north-east of Rugby. Thence it flows *via* Rugby, Church Lawford, Wolston, Bubenhall, Stoneleigh, Ashow, Warwick, and Stratford-on-Avon, onwards past Evesham, into the Severn at Tewkesbury.

[1] 'Lichfield Memoir,' p. 219.

[2] A full description of the portion of the Avon basin that lies in Northamptonshire, the site of its source, and its tributaries, has been given by Beeby Thompson in *Journ. Northants. Nat. Hist. Soc. and F.C.*, vol. xxii (1923), pp. 1-13.

The river drains a tract composed of Lower Liassic, Triassic (Keuper Marl and Lower Keuper Sandstone), and Coal Measure beds, on the surface of which—and especially on that of the Keuper Marl and Lower Lias—are, locally, deposits of sand and gravel (Superficial Deposits).[1] Small springs issue from the Superficial Deposits and Lower Keuper Sandstone, but, speaking generally, springs of any size are few, and the water contributed to the parent river is mainly the product of surface-drainage. Prof. W. S. Boulton states that ". . . the river Avon at Leamington has a minimum flow of 31,000,000 gallons in twenty-four hours."[2]

The town of Rugby is dependent on Avon water for its domestic supply : if ever there were a demand for a large supply in the Warwickshire portion of the Avon basin it is probable that attention would have to be directed to the river or one of its tributaries if it were not decided to go far afield.

For a number of obvious reasons it is highly important to maintain the Avon water as free from pollution as possible. Rugby, Coventry, Leamington Spa, Warwick, Southam, and a number of smaller places, discharge their sewage effluents either direct into the Avon or per tributaries, and it is very satisfactory that the condition of the water is at regular intervals carefully tested by the County Medical Officer of Health and his staff and recorded in his Quarterly Reports.[3]

TRENT BASIN

River Tame.—This river, together with its tributaries the Cole, Blythe, Bourne, Anker, and less important streams, drains the northern portion of the county, and carries off the water into the River Trent near Croxall in Derbyshire. The tract it drains is floored mostly with Keuper Marl and Coal Measures ; but within it also occur small tracts floored with Archaean, Cambrian, Bunter, and Lower Keuper rocks ; while deposits of sand and gravel and boulder-clay (Superficial Deposits) occur locally on the surface of the ' solid ' rocks—especially on that of the Keuper Marl.

The waters of the River Blythe at Whitacre, and of the River Bourne at Shustoke, are stored in reservoirs belonging to the Birmingham Corporation. Before the Welsh Scheme these sources of supply were important ; but now they are used as a stand-by for Birmingham ; but a quantity, up to 2,000,000 gallons a day, is (by agreement) available for pumping into the Coventry Corporation's Coundon reservoir for the supply (*pars*) of that city.

Noticeable alluvial stretches border the Tame between Birmingham and Tamworth, and are very liable to flooding.

[1] An account of ' The Upper Basin of the Warwick Avon ' has been given by Charlotte A. Simpson, ' Geographical Teacher,' Autumn Number, 1914. *The Geogr. Assoc.*

[2] ' The Water Resources of the Birmingham District,' *The Engineer*, 1920, p. 647.

[3] These are the reports that are referred to by the Standing Committee on Rivers Pollution in their Report on ' River Pollution and Fisheries,' 1924, p. 23, para. 2.

As in the case of the water of the River Avon, that of the River Tame is carefully tested by the County Medical Officer of Health and his staff, more particularly to keep a check on pollution.

THAMES BASIN

The area in this basin embraces the dip slope of Edge Hill, the valley between it and the Dassett Hills, the main portion of these hills, and low ground to the east. The low ground is floored with Lower Lias ; the higher ground is composed of Middle Lias—Sandy Beds succeeded by Marlstone. The whole is drained by tributaries of the Cherwell, which empties itself into the Thames at Oxford. Many small springs issue from at or near the base of the Sandy Beds of the Middle Lias, and a number are drawn upon for private and village supplies ; but the bulk of the water carried off by the streams is the product of surface drainage.

II.—WATER SUPPLIES OF RURAL DISTRICTS

Alcester Rural District

This Rural District is almost entirely on the Keuper Marl; only very small tracts—the most important of which is that at and around Wilmcote in Aston Cantlow parish—are on Lower Lias. Flowers' Brewery Boring, Stratford-on-Avon (p. 134), and the Claverdon Boring (p. 67), proved 604 and 763 ft. respectively of Keuper Marl, so it may be taken that the maximum thickness in this Rural District is not much under 900 ft.

In the Keuper Marl, at from 120 to 160 ft. below its upper limit, comes a bed of sandstone, known as the Arden Sandstone.[1] This sandstone is fairly persistent, attains a maximum thickness of about 25 ft., but locally is represented merely by bits of blue shale. The sandstone contains limited quantities of water, and this fact was early appreciated for many of the villages in this rural district are situated thereon. In addition, a number of useful springs issue therefrom—notably The Dingle and Slad Springs (p. 25).

Locally, on the irregular surface of the marl and sandstone are deposits of sand and gravel (Drift). These contain water; but wells sunk in them are especially liable to pollution if inadequately protected.

Alcester

Waterworks. Owned by the Alcester Waterworks Co., Ltd. Supply parts of the parishes of Alcester and Arrow (Alcester Rural District).

Sources of Supply.—(1) Well (about 25 ft. deep and 6 ft. 6 in. in diameter) in Keuper Marl (said to tap a spring) within the Pumping Station; (2) Borehole (about 150 ft. deep) between the Pumping Station and the road; (3) Spring from gravel (on Keuper Marl) of Arrow-side river-terrace in field east of the southern end of the railway-bridge over the Arrow. The water gravitates to the Pumping Station.

The average daily quantity of water obtained is 31,000 gallons, and a further 35,000 gallons per day could be obtained.[2]

Quality of Water.—Good. Hard and no action on lead.

Sewage Scheme Borings

No. 1.—'School Boring'. At the School, School Road. Made in 1877. Particulars of strata communicated by Messrs. LeGrand, Sutcliff & Gell, Ltd.: of water-level and yield, by C. B. Machin, Sanitary Surveyor and Inspector, Alcester Rural District Council.

[1] A useful geological paper for this district is that by Dr. C. A. Matley, 'The Upper Keuper (or Arden) Sandstone Group and Associated Rocks of Warwickshire,' *Quart. Journ. Geol. Soc.*, vol. lxviii (1912), pp. 252-280, and map, pl. xviii.

[2] 'Return as to Water Undertakings in England and Wales' (1915), p. 175. *Local Gov. Bd.*

Height above O.D. 140 ft.

		Thickness Ft.	Depth Ft.
[Alluvial]	Gravelly clay and marl	15½	15½
[Keuper Marl including 'Blue Shale' ? The Arden Sandstone]	Blue shale and red marl	16½	32
	Red marl	13	45
	Gypsum and marl	7	52
	Marl	10½	62½
	Red marl and rock	10½	73
	Marl and rock	7	80

Water-level.—Rises 2 ft. above road-level. Yield, 432 gallons per hour. The water flows into a flushing-tank and gravitates down the sewer.

No. 2.—'GUNNINGS-BRIDGE BORING'. In the main road, Alcester to Henley-in-Arden, at the end of the town. Made in 1897. Height above O.D. 133 ft.

[Keuper Marl including Arden Sandstone] 90 ft.

Water-level.—Rises 1 ft. above road-level. Yield, 600 gallons per hour (3/1/1921).

Works a ram which raises water to a flushing-tank near the Isolation Hospital, from which the water gravitates down the sewer.

Great Alne

'PERK'S BORING'. In field east of Church. Supplies G. Perk's house—The Lodge.

[Keuper Marl below the horizon of the Arden Sandstone]. About 80 ft.

Analysis, p. 26.

GREAT ALNE HALL SUPPLY. The water is obtained from a spring from the Arden Sandstone a little over half a mile north-eastward of the Church; it gravitates into a tank; and thence to the Hall and four houses.

SPRINGS

The springs, of which gaugings are given below (communicated by Cyril B. Machin, Sanitary Surveyor and Inspector to the Council), were investigated as sources of a public piped supply to Great Alne.

Spring	Date of gauging	Yield in gallons per 24 hours	Analyses
Dingle Spring	October, 1922	10,000	p. 26
Slad Springs	October, 1922	1,728	p. 26
	May, 1923	3,700	
Two springs near the Slad Springs	May, 1923	1,995	

Kinwarton

Kinwarton Rectory Spring on the glebe, not far from the Rectory, in November 1921 was yielding 27½ gallons per minute (C. B. Machin).

Salford Priors

A spring near the Ban Brook, a quarter of a mile north-west by west of the Railway Station, issuing from Superficial Deposits on Keuper Marl, was yielding 40 gallons per minute in October, 1920 (C. B. Machin).

ANALYSES

1, 2. Slad Springs, Great Alne. (1) 30.4.23. (2) 17.5.22. (From the Arden Sandstone).
3. Dingle Spring, Great Alne. 19.10.22 ... ... (Ditto).
4, 5. Perk's Boring, Great Alne. (4) 22.5.17. (5) 9.1.24. (Keuper Marl).

Analyses by Messrs. Bostock Hill and Rigby, Birmingham.

	In parts per 100,000[1]				
	1	2	3	4	5
Free and saline ammonia ...	0·0005	0·002	0·004	trace	0·0015
Albuminoid ammonia ...	0·010	0·040	0·044	0·008	0·008
Chlorine in chlorides ...	1·600	1·800	2·200	2·100	2·400
Nitrogen in nitrates and nitrites	0·220	0·220	0·220	trace	0·110
Oxygen absorbed from permanganate at 80°F. in 4 hours	0·036	0·511	0·450	0·056	0·040
Do. after filtration	—	0·156	—	—	—
Total solids dried at 100°C. ...	60·000	86·000	68·000	78·000	69·000
Hardness : Temporary ...	9·3	18·500	—	—	—
Permanent ...	38·55	30·000	—	—	—
Total	47·85	48·500	—	—	—

Appearance :—
1, 4. Bright, few small particles.
2. Slightly turbid, very many small particles.
3. Turbid, very many small particles.
5. Bright, many small particles.

Remarks :—
1, 5. Safe for drinking purposes.
2, 3. Unsuitable, in present condition, for drinking.
4. Fairly satisfactory.

Atherstone Rural District

The Council supplies parts of the parishes of (1) Baddesley, Baxterley, Bentley and Merevale ; (2) Atherstone (parish and town), Grendon (adjacent to Watling Street), Hartshill (including Chapel End), Mancetter (Ridge Lane), Merevale (part adjacent to Atherstone Railway Station), Oldbury (part), Polesworth (portion), Baddesley (the part known as Lower Baddesley adjacent to the Watling Street) ; (3) Polesworth (see p. 28).

Sources of Supply.—(1) Supply in bulk from the Baxterley Well of the Baddesley Collieries (the water from which is delivered into

[1] To convert parts per 100,000 into grains per gallon multiply by 0·7.

the Bentley reservoir—the property of the Collieries Company); (2) Boreholes at Warton (see p. 29); (3) Borehole at the Polesworth Waterworks (see p. 28). The average daily quantity of water derived from each source is respectively (1) 50,000 gallons; (2) 150,000 gallons; (3) 50,000 gallons.

Ansley

BIRCHLEY HEATH WELL.[1]

Belongs to the Atherstone Rural District Council. Site marked 'Water Works' (near Tithe Farm on the Geological Survey map, New Series, Sheet 169). This source of supply has been abandoned as the supply failed. Made in 1882, and particulars communicated by Baldwin Latham and published in *Rep. Brit. Assoc.* for 1890, p. 374.

Height above O.D. 500 ft.

Well (Diameter 9 ft.: first 30 ft. lined with brickwork and cement to exclude all surface water):—

		Thickness Ft.	Depth Ft.
Lower part of Keele Group	Red marl	10	10
	Soft red sandstone	2	12
	Hard red sandstone	16	28
	Marl interstratified with hard bands of red sandstone ...	11	39
	Hard red and grey sandstone ...	10	49
	Red sandstone	10	59
	Very hard red rock	6	65
	Hard red and grey rock	7	72

H. J. Coleby, Engineer and Surveyor, Atherstone R.D.C., has remarked[2]:—"At the bottom of the well a 12 in. diameter borehole was sunk, but as this was found to have been filled up with clay, presumably, no benefit by way of increased yield was derived therefrom.

"When first sunk, this well yielded 300,000 gallons per day on the test pumping, and for some years a constant supply of about 100,000 gallons per day was obtained therefrom. The yield, however, gradually decreased, until at the present time [January, 1914] the average quantity obtained is only 55,000 gallons per day, while it has sunk so low as 25,000 gallons per day.

"The author regards this as an indication that the underground reservoir of water has been exhausted by continuous pumping, and that the amount which can now be obtained is governed entirely by the rainfall and the area of outcrop.

"This latter is very difficult to determine, the site being near to the eastern boundary of the Warwickshire Coal Field, and the ground being very much faulted. The recent investigations of the Geological Survey tend to show that, so far from there being a large

[1] Also referred to in literature as the 'Ansley' Well, and 'Atherstone' Well.

[2] *Trans. Inst. Mun. and Cy. Eng.*, vol. xl (1913-14), p. 393.

and continuous area of water bearing rocks, these are so divided by beds of impervious marls and broken by faults, that the actual watershed drained by this well is very limited in extent, and is probably confined to the immediate vicinity of the well itself.

"This source of supply must therefore be regarded as a failure . . ."

The Ansley Hall Pumping Station Well.

The property of The Ansley Hall Coal and Iron Co., Ltd. Situate between Moor Wood and Ansley Hall Colliery.

Height above O.D. 450 ft.

Basement beds of the Middle Coal Measures (including the basal sandstone and conglomerate), and ? Cambrian	69 ft.

Baxterley

Baxterley Well.[1] The property of the Baddesley Collieries.

Baddesley Collieries.—Furnish supplies in bulk to Atherstone R.D.C. and Tamworth R.D.C.

Source of Supply.—Well [270 ft. deep on Bentley Common] at Baxterley. Yield not known.

Quantity of Water supplied.—The daily average is 65,000 gallons. Supply is constant.

Quality of Water.—Satisfactory.

In a Report Prof. Charles Lapworth said:—"At Baxterley the 100-Feet and the 4-Feet Sandstones were sunk through, and the total yield was 700,000 gallons per day. This yield lasted for two years until it was tubbed back."

Hartshill

Moor Wood Well. South-west of Hartshill.

Height above O.D. 450 ft.

Cambrian. Stockingford Shales with diorites	172 ft.

Yield.—Very small.

Polesworth

Polesworth Waterworks, boring (Atherstone Rural District Council). At the 't' of 'Polesworth W.W.' on the one-inch Geological Survey map, New Series, Sheet 155, one mile north-north-east of Polesworth Church. Close to the stream. Made in 1887.

Height above O.D. about 220 ft.

[1] 'Return as to Water Undertakings in England and Wales' (1915), p. 331. *Local Gov. Bd.*

Borehole (5 in. diameter) :—
Keele Group[1]— Keele sandstones } Sandstone[2] ... 60 ft.

Yield.—An average of 50,000 gallons per day.

H. J. Coleby,[3] Engineer and Surveyor to the Council, says :—" In 1906 the author made a test of this boring by pumping day and night for a week with all the power then at his command, and was able to obtain 104,000 gallons per twenty-four hours without materially lowering the water level. This level, when pumping, is about 15 feet below the surface . . ."

The water from this borehole is pumped to a reservoir—capacity 56,000 gallons—situate between Polesworth and Dordon, from which is supplied the whole of the parish of Polesworth, with its hamlets of Dordon, Warton, Hall End, and Freasley, and that part of the parish of Grendon known as Grendon Common.

WARTON PUMPING STATION (Atherstone Rural District Council).

Situate on the east side of the road, about a mile E. by N. of Polesworth Church. Made in 1913 by the New England Boring Company. Particulars communicated by H. J. Colcby, Engineer and Surveyor to the Council, and published in the 'Lichfield Memoir,' pp. 281, 282. See also H. J. Coleby, *Trans. Inst. Mun. and Cy. Eng.*, vol. xl (1913-14), p. 398.

Height above O.D. 262 ft. Shaft (13 ft.) and boring (20 in. in diameter to 300 ft.) :—

		Thickness Ft.	Depth Ft.
Keuper Sandstone	Red marl	21½	21½
	Grey sandstone with pellets of green marl	15½	37
	Red marl	6	43
	Grey sandstone	14	57
	Red marl	1½	58½
	Grey sandstone with fine breccia	5½	64
Bunter Sandstone (with Pebble Beds)	Red marl	3	67
	Sandstone with red and green marl partings	6	73
	Reddish-brown sandstone	4	77
	Reddish-brown sandstone with green marl-partings	6½	83½
	Grey sandstone	12½	96
	Red and brown sandstone	12	108
	Grey sandstone	1	109
	Red shaly marl	1	110
	Brown and yellow variegated sandstone	16	126
	Red shaly marl	4	130
	Red sandstone	7	137
	Brown and grey variegated sandstone	9	146

[1] Lower part below the *Spirorbis* Limestone. 'Lichfield Memoir,' p. 63.
[2] 'Atherstone and Charnwood Forest,' *Mem. Geol. Surv.*, 1900, p. 29.
[3] Coleby, H. J., *Trans. Inst. Mun. and Cy. Eng.*, vol. xl (1913-14), p. 394.

		Thickness Ft.	Depth Ft.
Bunter Sandstone (with Pebble Beds)	Red and green shaly marls	6	152
	Loose pebbles	1	153
	Grey sandstone	2	155
	Hard conglomerate	2	157
	Grey sandstone	3	160
	Friable white sandstone with some pebbles and with bands of brown sandstone of closer texture ...	30	190
	Brown sandstone	4	194
	Red shaly marl	4	198
	Reddish-brown sandstone	1	199
	Red and green shaly marls	5	204
	Brown and yellow variegated sandstone	96	300

Lined with steel tubes 18 in. internal diameter to 75¼ ft.

Do. from 155½ to 212½ ft. to keep out loose sand.

Water levels.—Standing, 41 ft. below surface; falls to 63 ft. on full pumping, rising 18 ft. in 25 minutes when pumping ceases, and to normal level in 24 hours.

Yield.—After prolonged test, 10,000 gallons per hour.

WARTON PUMPING STATION (Atherstone Rural District Council).

Made in 1922 and particulars communicated by Messrs. C. Isler and Co., Ltd. Height above O.D. 262 ft.

		Thickness Ft.	Depth Ft.
	Dug hole (8 ft. × 7 ft. × 6 ft.)	8	8
	Borehole (diameter 24 in. in the clear) :—		
[Keuper Sandstone]	Red marl	13	21
	Grey sandstone	13	34
	Red marl	8	42
	Grey sandstone	18	60
[Bunter Sandstone: some Pebble Beds]	Red marl and grey sandstone ...	15	75
	Grey and red sandstone	35	110
	Red marl and sandstone	2	112
	Grey sandstone	3	115
	Red marl and sandstone	3	118
	Red and grey sandstone	3	121
	Red marl and sandstone	4	125
	Red and grey sandstone	8	133
	Red marl	4	137
	Red marl and pebbles	1	138
	Grey sandstone	2	140
	Conglomerate	3½	143½
	Grey sandstone	2	145½
	Conglomerate	4½	150
	No core : ? Conglomerate	12	162
	Grey sandstone and rock	1	163
	No core	12	175
	Red marl and brown sandstone and conglomerate	2	177
	Conglomerate	10	187
	Red and brown marl	1	188

		Thickness Ft.	Depth Ft.
[Bunter Sandstone: some Pebble Beds]	Grey sandstone	2	190
	Red and brown marl and sandstone	4	194
	Grey sandstone and pebbles ...	4	198
	Red sandstone	1	199
	Red and brown marl	½	199½
	Grey sandstone with pebbles ...	3½	203
	Conglomerate	1	204
	Grey and red sandstone	46	250
	Red sandstone	35	285
	Red marl	2	287
	Red sandstone	17	304

Lined with 87 ft. of tubes, 22½ in. in diameter, top 6 ft. below surface.

Water-levels.—Standing, 46 ft. below surface; pumping, at the rate of 15,000 gallons per hour, 76 ft. below surface, at which it remained stationary, and recovered to 46 ft. below surface in half an hour.

Yield, 15,000 gallons per hour.

The Bunter Pebble Beds probably rest on

Keele Group	Marls: about	50 ft.
	Keele sandstones, thick-bedded, massive, with a band of breccia in the upper part dipping ? about 10° to the east.	

The sandstones come to the surface in the vicinity of the Polesworth Waterworks (p. 28), and it is in them that the borehole at these waterworks is sunk.

Warton Trial Well.

Trial well sunk for the Atherstone Rural District Council five-twelfths of a mile north by east of Warton Church.

Well (50 ft.) and boring (50 ft.):—	
Lower Keuper Sandstone ...	100 ft.

G. Barrow said ('Lichfield Memoir,' p. 161):—". . . a well a little north of Warton penetrated 100 ft. of Keuper Sandstone (Waterstones) without reaching its base."

Result:—Abandoned owing to excessive hardness of the water.

Brailes Rural District

This Rural District is situate in the extreme southern part of Warwickshire, mostly on the undulating clay-lands of the northern portion of the Moreton Valley between the Edge Hill and 'Oxfordshire Downs' on the east and the North Cotteswolds on the west. The clay-lands have here and there on their surface patches of sand and gravel (Superficial Deposits): patches that are relics of larger spreads which have been reduced owing to the headward growth of the fairly steep-falling River Stour—a tributary of the Avon, which

is in turn a Severn stream—and its numerous small tributaries, which eating through the Superficial Deposits, have also deeply furrowed the subjacent Lower Lias. The Lower Lias is anything up to 700 ft. in thickness, and it is useless boring into it (for such little water as might be encountered would be hard and probably 'salty') or through it in search of water. The Superficial Deposits on its surface are useful as sources of small supplies: Great Wolford, Idlicote, and Stretton-on-Fosse, derive supplies (piped) therefrom. The Middle Lias succeeds the Lower Lias at Ebrington Hill and in the hills along the eastern margin of the district. The Middle Lias consists of Sandy Beds succeeded by Marlstone—the 'Banbury Iron-stone'. From at or near the base of the Sandy Beds numerous small springs issue: certain are used for the purpose of supplies (piped) for Ilmington (below Ebrington), Lower Brailes, Upper Brailes, Cherington, Little Compton, the Tysoes, and Wichford. The Upper Lias succeeds the Middle and is itself succeeded by 'Inferior' Oolite in the parishes of Brailes, Little Compton, Long Compton, and Wichford. The Oolite is composed principally of the sub-divisions, the *Scissum*-Beds (in Northamptonshire, the 'Northamptonshire Iron-stone') and Chipping Norton Limestone. Water is thrown out from it by the subjacent Upper Lias clay, but the springs are small: certain at Brailes Hill, Oakham Hill, and The Coombs are used for the purpose of supplies (piped) to Upper Brailes, Little Compton, and Long Compton, respectively. The stream which flows through the parish of Little Compton—the extreme southern parish—falls into the Evenlode, a small tributary of the Thames.

There are no springs worth mentioning running to waste in the district.

Brailes

There are four piped supplies at Brailes, all belonging to the Rural Council, namely:—

1. The overflow (about 1,000 gallons per day) from a well, tapping a spring from the Sandy Beds of the Middle Lias, situate half a mile eastward of Lower Brailes, comes to a reservoir from which it is piped to Lower Brailes.

2. A spring (about 200 gallons per day) from the Sandy Beds of the Middle Lias at Hobs Hole (under the '5' of the spot-level 458, 1-inch Ordnance Survey Map, Sheet 201, Third Edition), Upper Brailes, supplies a few cottages in Upper Brailes.

3. A spring from the Sandy Beds of the Middle Lias (at the 'r' in Upper of Upper Brailes on the 1-inch Ordnance Survey Map, Sheet 201, Third Edition) near the house for Tusbrook Farm, in Upper Brailes village, is collected by agricultural pipes, and the overflow (500 to 600 gallons per day) not required by the farm-house is taken by the Council.

4. A spring from the Oolite, from which it is thrown out by the Upper Lias clay, near the barn on Brailes Hill, $1\frac{1}{8}$ miles west by

5° south of Lower Brailes Church, is piped to the fountain at Upper Brailes, supplying Fanthill and Brailes Hill farms *en route*. The water at the fountain is not used for drinking purposes. The 'Tusbrook Spring' was used by the Brailes Brewery and only became available for use by the Council when the brewery closed. The brewery made an abortive attempt to obtain water by boring into the Lower Lias to a depth of some 200 ft.

Cherington

The springs constituting the source of H. Warriner's private supply to the village issue from the Sandy Beds of the Middle Lias at about half a mile to the south-south-west. The Rural Council have 'Mag Well'—a pump over a well supplied by pipe from a spring in an orchard.

Compton Wyniates

The source of the Marquess of Northampton's supply is a spring at a locality known locally as 'the Sally Beds.'

Great Wolford

The Great Wolford supply formerly belonged to Lord Redesdale, but since the estate was split up a Committee of Parishioners has looked after it. The springs are near the village and issue from Superficial Deposits resting on Lower Lias: the water is raised by a ram and laid on to standposts.

Halford

A well sunk here, 55 ft. deep in Lower Lias, on the opposite side of the road to 'The Lion', struck water 'sufficiently salty for a Spa'. The water is said to have come from a band of 'black crumbly rock' at about 54 ft. down. There is a deep well pump over the well, but it is not used.

Ilmington

The source of supply to Ilmington is Wedgnock Spring near the road to Foxcote at about a quarter of a mile south by 15° west from Ilmington Church. The spring issues from the Sandy Beds of the Middle Lias and yields about 8,000 gallons per day. The water runs into a tank from which it is piped to fountains in the village.

Ilmington Mineral Spring.

On the six-inch map this spring is marked 'Newfoundland Well (Chalybeate)', but locally it is known as Lord Capell's Spring or Well. The water issues from the Middle Lias.

About the time that the spring was discovered, Dr. William Cole, in his 'Treatise of Apoplexies' (1684), said that the "Ilmington Chalybeat Water" was second to none.

In the following year (1685) Samuel Derham published 'Hydrologia Philosophica or an Account of Ilmington Waters in Warwickshire; with Directions for the drinking of the same.' In

the preface he referred to the spring as the " . . . New-found Spring, by some called Balmoore Waters. . . . This may also deserve the name of Ilmington Spaw from its brackishness."

Dr. William Thomas, in his 2nd ed. of Sir William Dugdale's ' The Antiquities of Warwickshire ', 1730, also speaks of the spring (p. 631).

In 1890, W. G. Fretton referred to this spring as " a strong chalybeate spring."[1]

Little Compton

The upper part of the village has a piped supply (private) from a spring from the Oolite, from which it is thrown out by the Upper Lias clay, at Oakham Hill.

Long Compton

The source of the Council's Supply is Coombe Spring from the Oolite, from which it is thrown out by the Upper Lias clay, at a mile and a quarter south from Long Compton Church. The water is piped to standposts in the village.

Oxhill

The Council has provided two pumps in the village over wells in the Lower Lias. The water of the one is ' fresh ', but of the other, saline.

Pillerton Hersey

A spring, from limestone-bands amid clay (Lower Lias), discharges into a pool here, never fails, and in dry periods cattle are brought to the pool from miles around.

Pillerton Priors

Pillerton Priors (or ' Upper Pillerton ') is on a sand-bed (Superficial Deposits) resting on Lower Lias clay. There is a spring by the roadside and a public pump.

Stretton-on-Fosse

The upper part of the village is on a sand-bed (Superficial Deposits) resting on Lower Lias clay. The sand ' peters out ' in the northern part of the village, and, where it does so, springs issue.

Near the pool, about 300 yards west-south-westward of the Church, a well was dug some 12 ft. deep in sand, water encountered, and the ' well ' was converted into a reservoir. This is the source of the Council's supply to the village.

Sutton-under-Brailes

The source of Arthur Shepard's private supply to the village is a spring from the Sandy Beds of the Middle Lias at a quarter of a

[1] *Proc. Warwickshire Nat. and Arch. F.C.* for 1890, p. 42.

mile north-west by west of the Church. There is a tank at the spring and another near the single standpost.

Tysoe

There are three piped supplies in this parish belonging to the Trustees of the Tysoe Utility Estates. They are derived from springs from the Sandy Beds of the Middle Lias :—

1. At about half a mile south of Upper Tysoe for Upper Tysoe ;
2. Near Winchcombe Farm for Middle Tysoe ;
3. Near Old Lodge Farm for Lower Tysoe. This spring is a strong one.

Whatcote

A borehole on Kirby Farm is about 200 ft. deep in Lower Lias. Salt water was encountered, but it is used at the farm, the water being raised by a windpump to a reservoir of from 15,000 to 20,000 gallons capacity.

Wichford

Wichford has two separate piped supplies. Both have as sources of supply springs issuing from the Middle Lias : the one at Holy Well, in the northern part of Wichford Wood ; the other close to the west side of the road three-eighths of a mile east-south-east of the Church. The overflow of the latter has been piped to a well (fitted with a pump) by the Council.

ANALYSES

BRAILES RURAL DISTRICT

1. Oxhill. Spring at Knollands Farm from Superficial Deposit on Lower Lias.
2. Pillerton. Well (Rev. H. Mills).
3. ,, Village (Pillerton Hersey) spring. From Lower Lias.
4. Stretton-on-Fosse. New well in 12 ft. of sand (Superficial Deposit) resting on Lower Lias.
5. Whatcote. Tap at Kirby Farm (from borehole in Lower Lias).

Analyses by Messrs. A. Bostock Hill & Rigby.

	Parts per 100,000				
	1	2	3	4	5
Date of receipt of sample ...	14.9.23	11.8.23	11.8.23	29.6.04	3.1.12
Free and Saline Ammonia ...	0·001	0·003	0·003	0·005	0·001
Albuminoid Ammonia ...	0·008	0·006	0·006	0·008	0·016
Chlorines in Chlorides ...	3·300	2·8	—	2·000	6·2
Nitrogen in Nitrates and Nitrites	0·330	0·27	trace	0	0·11
Oxygen absorbed from permanganate at 80°F. in 4 hours	0·076	—	—	0·144	0·186
Total Solids dried at 100°C ...	120	56	50	30	19·8
Hardness : Temporary ...	—	—	—	8·56	21·85
Permanent ...	—	—	—	8·58	50·75

Appearance :—	Remarks :—
1. Bright ; few small particles	1. Reasonably safe for use for drinking purposes.
2, 3. Bright ; few particles.	2, 3. Ditto.
4. Pretty clear ; many large particles.	4. Suitable water for a village supply.
5. Pretty clear ; many small particles.	5. Very hard water containing a large quantity of saline matter in solution and a fair amount of organic matter. Unsuitable for a village supply.

Coventry Rural District

C. G. Parrott, Sanitary Inspector, Coventry Rural District Council, informs me :—" The only spring of which I have knowledge that is used for domestic purposes is one situate on Aldermoor in the parish of St. Michael Without. It is caught in a dip well and about ten cottages draw their supplies therefrom."

Foleshill Rural District

The geology of this Rural District—with the exception of portions of the parishes of Binley and Willenhall, which come in Sheet 53 N.W. (Old Series), Geological Survey—is shown on the Geological Survey map, New Series, Sheet 169.

Bedworth

Bedworth Waterworks. First a well was sunk (? 80 ft.) : then a boring (150 ft.) made from the bottom (total ? 230 ft.) ; but the yield was insufficient. Next a boring was made near by to a depth of 294 ft. (see p. 38) ; but again the yield was insufficient, and gradually failed. So well and boreholes were abandoned and water was obtained by the Council from Newdigate Colliery. Mr. A. E. Newey, Engineer and Surveyor, Foleshill Rural District Council, informs me :—" The original supply from the Newdigate Colliery came from a spring in the pit shaft, and this was sufficient for the requirements at Bedworth and also for the Colliery, except in very dry weather. The agreement with the Colliery was that they should have sufficient water for their requirements before supplying Bedworth, and, in consequence, a shortage occurred [and still does] at times, and it was decided to put down a borehole [p. 38] . . . but the quantity of water, of course, varies considerably from the shaft." This well is in the Halesowen Sandstone Group. It commences immediately to the east of the outcrop of the Index (*Spirorbis*) Limestone, and some 350 yds. to the west of that of the upper limit of the 100-Feet Sandstone. The outcrop of these beds is hidden under Glacial beds. The gradual failure of the supply is attributable to the nearness of the outcrop of the 100-Feet Sandstone and the abstraction of water exceeding the rate at which the water could be replaced by rain ; owing mainly to the impervious covering to the sandstone of Glacial deposits.

Astley

NEWDIGATE COLLIERY BORING. Made in 1914 and particulars communicated by Messrs. C. Isler and Co., Ltd.

		Thickness Ft.	Depth Ft.
[Keele Group]	Made ground	1	1
	Mould	2½	3½
	Red marl	66½	70
	Red sandstone	5	75
	Strong red marl	5	80
	Sandstone and marl in layers ...	6	86
	Rocky marl	47	133
	Sandstone and marl in layers ...	7½	140½
	Sandstone	7	147½
	Hard marl	2	149½

Lined with 71 ft. of tubes, 11½ in. in diameter, top level with surface. Water level, 23 ft. below the surface. Supply, 8,544 gallons per hour.

ANALYSIS

Bedworth Waterworks. Newdigate Colliery, Astley.
Water supplied to Bedworth. See p. 36.

Result of Analysis

	Parts per 100,000
Free and saline ammonia	0·0005
Albuminoid ammonia	0·002
Chlorine in chlorides	4·100
Nitrogen in nitrates and nitrites ...	0·220
Oxygen absorbed in four hours at 80°F.	0·019
Total solid matter	50
Hardness: temporary	12·7
permanent	20·8
total	33·5

Bright, few small particles.
3rd May, 1924.

Newdigate Colliery.

Water taken from Newdigate Colliery, 300 yards deep, 14.9.09, from the same water-bearing rocks [100-Feet Sandstone] as supply the Clara Well, Griff. (See p. 107).

	Parts per 100,000
Free and saline ammonia	·014
Organic ammonia	·004
Chlorine in chlorides	41·9
Nitrogen in nitrates and nitrites ...	·11
Oxygen absorbed in 4 hrs. at 80°F. ...	·01
Total solids	134
Hardness: temporary	13·1
permanent	8·4
total	21·5

Remarks:—The amount of solid matter in solution is large. This is chiefly caused by the presence of a large quantity of salt, the chlorine figure being 41·9, which is equivalent to 48·3 grains of salt per gallon.

Bedworth

BEDWORTH WATERWORKS. Boring near the water-tower. Made in 1904. Height above O.D. 340 ft.

			Thickness Ft.	In.	Depth Ft.	In.
[Drift]	1.	Soil	1	3	1	3
	2.	Red sandy marl	23	9	25	0
	3.	Red bind	3	0	28	0
	4.	Red sandy marl with running sand	14	0	42	0
[Lower part of Halesowen Group (including the 100-Feet Sandstone)]	5.	Blue and red marl	12	0	54	0
	6.	Blue and red mottled marl ...	9	0	63	0
	7.	Red bind	17	0	80	0
	8.	Red rock	24	0	104	0
	9.	Mottled marl	16	0	120	0
	10.	Blue marl...	14	0	134	0
	11.	Coal	1	0	135	0
	12.	Hard blue bind	44	0	179	0
	13.	Grey sandstone with water ...	18	0	197	0
	14.	Blue rock binds	18	0	215	0
	15.	Grey sandstone with water—5,000 gallons per hour ...	79	0	294	0
	16.	Conglomerate				

Yield.—Tested to 5,000 gallons per hour. The supply, however, gradually failed and the borehole was abandoned.

CHARITY COLLIERY. This colliery shaft proved[1] :—

	Depth Ft.	In.
Drift	24	6
Halesowen Group	74	5
Etruria Marl	234	1
Two Yard Coal	495	5
Seven Foot Coal	592	0
Base of Coal Measures...	788	5
Stockingford Shales to	1032	6

In a Report Prof. Charles Lapworth said :—" The 100-Feet Sandstone [at the base of the Halesowen Group] was tapped in the sinking at Charity Colliery. Water was found in large quantity at first, but gradually decreased as the working proceeded. As only a few yards of the 100-Feet Sandstone were tapped in this Colliery, it is easy to account for the comparatively small supply. The 4-Feet Sandstone was pierced both in this Colliery and in Exhall, but little water was obtained, showing that this lowest band is comparatively valueless in this district."

Binley

BINLEY COLLIERY.

		Thickness Ft.	Depth Ft.
Trias	Keuper Marl		307
	Lower Keuper Sandstone		
Upper Coal Measures	Etruria Marl	46	353
Middle Coal Measures	Measures		750
	Two Yard Coal		
	Measures		808
	Slate Coal		

[1] Note on six-inch map, *Geol. Surv.*, Warwick 17 N.W.

E. C. Bond, Sanitary Inspector, Foleshill Rural District Council, informs me that "It was hoped to supply the many new houses near the Peel Conor Telephone Works, Stoke [see p. 41] with water from this Colliery; but it was found to be far too salty."

EXHALL COLLIERY. This Colliery proved[1]:—

	Ft.	In.
Drift	30	0
Index Limestone	52	0
Halesowen Series (base)	321	7
Etruria Marl (base)	505	0
Thick Coal: top	784	10
base	813	7
Seven Feet Coal (base)	861	11

In a Report Prof. Charles Lapworth said:—"The Exhall Pit shafts were sunk through the 100-Feet Sandstone [at the base of the Halesowen Group] down to the coals. When they were sunk originally a yield of about 1,500 gallons per minute, or about 2,000,000 gallons per day, was obtained for nearly two years. The quantity pulled off, however, diminished the 'come' of water to the Hawkesbury Pumping Station at Hawkesbury Stop, showing that the amount of water extracted at Exhall was far in excess of the natural yield. Still the amount of water in the 100-Feet Sandstone at Exhall must be very large, for it is said to have drowned out the shafts originally sunk (projected) and forced in the sides of one of the main shafts long after the mines were in working order."

E. C. Bond, Sanitary Inspector, Foleshill Rural District Council, informs me that:—"Salt water is pumped up from the workings at Exhall Colliery into the brook. This brook runs through Wyken Pool, and during one dry period, when the fresh water in the Pool was low, a very large number of fish was killed." (Analyses, p. 43).

Foleshill

HAWKESBURY PUMPING STATION.[2] Coventry Canal Company. Site marked on Geological Survey map, New Series, Sheet 169.

Height above O.D. 305 ft.

Well (depth, 120 ft.; diameter, 10 ft.):—

	Thickness Ft.	Depth Ft.
Drift [boulder-clay]	30	30
Lower Keuper Sandstone	65	95
Halesowen Group [lower part—100-Feet Sandstone]	25	120

Drift waters kept out of well. Very little water was met with in the sandstone until the bottom bed—"a very hard white sandstone"—was blasted: the water then burst in; the men had to escape, leaving all the sinking tools at the bottom, and the water rose at once to 10 ft. from the surface.

[1] Note on six-inch map, *Geol. Surv.*, Warwick 17 S.W.
[2] Hawkesbury Stop.

Water-level (rest).—According to R. C. Sinclair : before pumping 10 ft. below the surface ; after 10 days and nights *constant pumping* 25 ft. ; fills up in 3 hours to 10 ft. According to ' Coventry Memoir,' 69 ft. below surface. Yield, 1,500,000 gallons per 24 hours (' Coventry Memoir '). Quality of water.—Very pure and leaves but little incrustation in boiler (R. C. Sinclair).

Messrs. A. Herbert and Co.'s Foundry, Edgwick. Boring made in 1901 and communicated by Messrs. Dunn and Booth, 52 Peartree Street, Goswell Road, London, E.C.

Height above O.D. 310 ft.

		Thickness		Depth	
		Ft.	In.	Ft.	In.
Pit		6	6	6	6
[Corley Beds not far above Exhall Conglomerate]	Red sandstone	15	6	22	0
	Marl	4	0	26	0
	Red sandstone	11	6	37	6
	Marl	28	0	65	6
	Red sandstone	78	6	144	0
	Marl	5	0	149	0

Water-Level, 22 ft. ex surface.

Hawkesbury Lane Station (L.M. & S. Rly.). Height above O.D. 310 ft.

Boring (15 in. diam.) :—

?Basal beds of Keele, then Halesowen Group	303 ft.

Water-level (rest), 42 ft. below surface. Yield, 456,000 gallons per 24 hours.

Keresley

Coventry Colliery.

		Ft.
Exhall Conglomerate, to base of	...	438
Keele Beds	,, ...	1203
Halesowen Beds	,, ...	1627
Etruria Marl	,, ...	1781
Thick Coal	,, ...	2135
Seven Feet Coal	,, ...	2168

T. Eastwood says[1] :—" Water from fissures proved a serious obstacle to sinking. Down to 180 ft. the flow amounted to 500 gallons per minute. . . . The sandstones and conglomerates at the base of the Corley [Enville] beds yielded 2,600 gallons per minute in both shafts . . ."

Stoke

Copsewood Grange Boring. W. Andrews, *Proc. Warwickshire Nat. and Arch. F. C.* for 1897, p. 34 ; *Final Report Roy. Comm. Coal Supplies*, pt. ix, Appendix iv. Height above O.D. 270 ft.

[1] *Summ. Prog. Geol. Surv.* for 1919 (1920), p. 64.

	Thickness Ft.	Depth Ft.
[Drift and Keuper Marl] Keuper Marl ...	60	60
[Lower Keuper Sandstone] Grey Waterstones	82	142
[Corley Beds] Brown and red sandstones ...	27	169

PEEL CONOR TELEPHONE WORKS. Made (commenced Sept., 1923; completed April, 1924) and communicated by Messrs. C. Isler and Co., Ltd. Under the "C" of Copsewood Grange on one-inch Geological Survey map, New Series, Sheet 169.

		Thickness Ft.	Depth Ft.
[Drift]	Made ground	1	1
	Sandy marl	6	7
	Clay and stones	17	24
	Hard green shale	3½	27½
[?Lower Keuper Sandstone]	Conglomerate	2	29½
	Grey sandstone...	4½	34
	Red and green marl	1½	35½
	Red sandstone	2	37½
	Red and green marl	2½	40
	Grey sandstone...	6½	46½
	Red marl rock	10	56½
	Grey sandstone...	3½	60
	Marl rock	4	64
	Red sandstone	9	73
	Hard red sandstone	11	84
	Marl rock	16	100
	Red sandstone	1½	101½
	Marl rock	31½	133
	Red sandstone	14	147
[?Corley Group]	Conglomerate sandstone	15	162
	Conglomerate	3	165
	Conglomerate sandstone	7	172
	Marl rock	26	198
	Marl and sandstone in layers ...	12	210
	Marl rock	52	262
	Sandstone	17	279
	Marl rock	30	309
	Red sandstone	1	310
	Red marl rock	29	339
	Marl and thin layers of sandstone ...	16	355
	Grey sandstone...	20	375
	Conglomerate	4	379
	Red marl rock	13	392
	Grey sandstone...	3	395
	Marl	2	397

Lined with 27 ft. of 12 in. tubes top 3 ft. 6 in. below surface. 265 ft. of 10 in. tubes top 2 ft. 3 in. below surface. 142 ft. of 8 in. (perforated) tubes top 255 ft. below surface.

Supply, 10,940 gallons per hour. Water-levels (standing), 11 ft. below surface; (pumping), 42 ft. below surface.

Walsgrave-on-Sowe

ALEXANDRA PIT, WYKEN COLLIERY.[1]

	Depth Ft.
Red clay (Drift)	35
Waterstones [Lower Keuper Sandstone]	130
Etruria Marl	310
Top of Two Yard Coal	464
Base of Slate Coal	502

According to a Report by Prof. Charles Lapworth, a large quantity of water was tapped in the Lower Keuper Sandstone, but analyses were unsatisfactory—the water was very hard and contained a notable quantity of salt.

Withybrook

CLOUDESLEY FARM BORING. Site marked on one-inch Geological Survey map, New Series, Sheet 169. Made in 1887 by Messrs. LeGrand, Sutcliff and Gell, Ltd. Height above O.D. 440 ft.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Drift]	Soil	2	0	2	0
	Grey sandy clay	4	0	6	0
	Drift	45	0	51	0
	Brown sand	21	0	72	0
	Hard bands of brown sand		6	72	6
	Brown sand	6	0	78	6
	Grey clay		6	79	0
	Brown sand	11	0	90	0
	Sand and sandy clay	7	0	97	0
	Running sand	20	0	117	0
	Clay and sand	11	0	128	0
	Stiff brown clay	4	0	132	0
	Sandy clay	27	0	159	0
	Brown sand	20	0	179	0
	Stiff blue clay	4	6	183	6
	Brown sand	1	6	185	0
	Coal		4	185	4
	Brown sand	2	8	188	0
	Sand and bands of stone	3	0	191	0
	Running sand and gravel	6	0	197	0
	Blue clay	2	0	199	0
	Brown clay and stones	2	0	201	0
[Keuper Marl]	Red marl	3	6	204	6
	Freestone	1	0	205	6
	Red marl	7	6	213	0

Water-level (rest), 100 ft. below surface. Yield, supply abundant and rest-level only lowered 7 ft. when pumping 5,760 gallons per 24 hours. Quality of water.—Said to be poor and to smell 'gassy.'

[1] Note on six-inch map, *Geol. Surv.*, Warwick 22 N.W.

ANALYSES.

1. Foleshill. New well, Wheelwrights Lane. 13.1.23.
2. Exhall. Well, Frog Hall. 1.5.23.
3. ,, Water from Exhall Colliery Inlet :
4. From Exhall Colliery Reservoir. 20.9.22
5. Keresley. Well, Spring Hill. 22.1.23.
6. Willenhall. Chapel Farm. 14.2.08.
7. Withybrook. (From Glacial Sands).

Parts per 100,000

	1	2	3	4	5	6	7
Free & Saline Ammonia	0·001	0·008	0·002	0·120	0·001	0·000	0·000
Albuminoid Ammonia	0·018	0·022	0·012	0·070	0·012	0·010	0·008
Chlorine in Chlorides	3·300	2·900	62·500	149·000	10·000	5·400	1·200
Nitrogen in Nitrates and Nitrites ...	trace	0·110	trace	0·000	5·500	2·090	trace
Oxygen absorbed from permanganate at 80°F. in 4 hours ...	0·302	0·059	0·420	0·693	0·090	—	0·069
Total Solids dried at 100°C. ...	70·000	56·000	206·000	388·000	122·000	94·000	35·000

Appearance :

1. Brownish, very many small particles. Iron in suspension.
2. Bright, many small particles.
3. Slightly turbid, many large particles. Incubation satisfactory.
4. Brown, very many small particles. Incubation satisfactory.
5, 7. Bright, many small particles.

Remarks :

1. Will probably become satisfactory.
2. Unsuitable for drinking purposes.
3 & 4. High salinity.
5. Unsafe for drinking purposes.
6. Unfit for drinking purposes.
7. Good and safe water for drinking purposes.

FARNBOROUGH RURAL DISTRICT

The lower ground of this District is on Lower Lias ; the higher ground, the hills, is composed of the succeeding Middle Lias—Sandy Beds followed by Marlstone. A number of springs issue from at or near the base of the Sandy Beds, and it is noteworthy that all the villages—with the exception of Radway, which has, however, a piped service from the same geological horizon—are on or just below the Sandy Beds. Wells sunk at or near the base of the Sandy Beds would collect water, but if they entered much into the subjacent Lower Lias they would be liable to collect saline water. Water from the Middle Lias—from the Marlstone in particular—may be chalybeate.

When selecting a spring for a public supply care should be taken to see that the water is not merely issuing from slipped Sandy Beds because, if it is, the yield is liable to be subject to considerable seasonal variations.

Avon Dassett

The village is supplied by an undertaking belonging to the Avon Dassett Water Company. The source of supply is a spring from the Middle Lias at Bitham Hill. The daily average quantity of water supplied is 4,500 gallons. Contains some iron.

Avon Carrow Mansion.—Supplied from a well in the Middle Lias.

Farnborough

St. Botolph's Well.—This is a chalybeate spring from the Middle Lias which, at one time, was in much repute.

Radway

The village is supplied by an undertaking belonging to the Farnborough Rural District Council. The source of supply consists of two springs issuing from at or near the base of the Sandy Beds of the Middle Lias, situate half a mile due east of Radway Church.

Warmington

The village is supplied by an undertaking belonging to the Warmington Parish Council. The source of supply is a spring at the Hill, Court Close, Warmington. The daily average quantity of water obtained is 230 gallons, and a further 90 gallons per day could be obtained.

Meriden Rural District

The geology of this District is shown on the Geological Survey map, New Series, Sheets 168, 169.

Speaking approximately, the western portion of the District is mainly on Keuper Marl, at about 160 feet below the top of which the Arden Sandstone is developed ; the eastern, on the Coal Measures. The division-line between the two portions is the Western Boundary Fault of the Warwickshire Coalfield, adjacent to the western side of which, in the vicinities of Berkswell and Meriden, the Lower Keuper Sandstone emerges from beneath the Keuper Marl. Beneath Maxstoke Castle the Keuper Marl is about 300 feet thick ; below Moxhull New Hall, 700 feet or more.

Superficial Deposits (Boulder Clay and undifferentiated drift, sands and gravels) cover considerable portions of the Keuper Marl, and are the source of numerous small springs. The former Digby Estate Supply at Sheldon was obtained from a spring from the sand and gravel, the water of which was stored in a tank and piped ; and the former Hurst Lane Estate Supply, Castle Bromwich, from a well in similar deposits, the water from which was raised by a windpump.

Berkswell

This village derives its name from Berks Well—a dip well near The Schools fed by a strong spring from red sandstones in the Enville Group.

Coundon

THE COTTAGE WELL.—About 500 yards south of Coundon Court. Site marked on 1-inch Geological Survey map, New Series, Sheet 169. Made and communicated by Messrs. C. Isler & Co., Ltd.

Height above O.D. 390 ft.

		Thickness Ft.	In.	Depth Ft.	In.
	Dug well	6	0	6	0
	Boring (4-in. diameter) :—				
Enville Group (beds between the Allesley and Corley Conglomerates).	Red marl and pebbles ...	6	0	12	0
	Red marl	8	0	20	0
	Sandstone	16	6	36	6
	Stone		6	37	0
	Rock	5	0	42	0
	Red marl	15	0	57	0
	Sandstone	9	0	66	0
	Marl...	3	6	69	6
	Red marl	16	6	86	0
	Sandstone	7	6	93	6
	Red marl	12	0	105	6
	Sandstone	1	0	106	6
	Red marl	31	9	138	3
	Red marl and rock ...	1	9	140	0
	Red marl	2	6	142	6
	Red stone and marl ...	1	6	144	0
	Red rock	5	0	149	0
	Red marl and rock ...		9	149	9
	Rock	1	0	150	9

Rest-level, 48 ft. below the surface. Supply.—Tested to 360 gallons per hour.

Fillongley

Fillongley has a piped supply that was installed by the Rural District Council in 1899. The source is a well tapping a spring.

The water gravitates to a reservoir from which it is laid on to the village.

Maxstoke

MAXSTOKE CASTLE LODGE BORING. At the lodge a quarter of a mile east of the Castle. Made in 1906 by Messrs. James Smith & Sons, 220 St. Vincent St., Ladywood, Birmingham, and particulars communicated by H. L. Tangye, Esq.

Height above O.D. about 255·3 ft.

Keuper Marl	Marls, with a few feet above the bottom, very slight traces of white sandstone (?L. Keuper Sandstone)	300 ft.

Result.—Water excessively hard (permanent and temporary hardness). A quantity of about 350 gallons was pumped for one hour, but then the supply failed.

Wishaw

Moxhull New Hall Boring. Keuper Marl. Not bottomed at 700 feet.

Monks Kirby Rural District

The distribution of the geological formations in this Rural District is shown on the 1-inch Geological Survey map, New Series, Sheet 169, Drift.

The Rural District is on Glacial Boulder Clay and associated sand and gravel. A boring made at Cloudesley Farm, just outside this Rural District on the west, revealed that the Glacial Deposits were there 201 feet thick, while another at Ullesthorpe, a little outside the District on the east in Leicestershire, proved 144 feet without reaching their base. Consequently the Glacial Deposits may be taken as anything up to 201 feet in thickness in this District.

Except for Willey, which is on Boulder Clay, the villages in this district are situate mainly on the water-bearing associated Glacial sands and gravels.

The entire Rural District is dependent on wells, from 15 to 60 feet deep. Supplies are generally adequate, and relatively few ran dry during or after the drought of 1921. As regards quality the well waters conform to the average ; they are very hard with a good deal of both permanent and temporary hardness.

Except under a portion of Pailton Pastures, where the Glacial Deposits rest on Lower Lias and Rhaetic, borings through the Deposits would enter the Keuper Marl.

Wibtoft

Tithe Platts Farm. Boring (diameter 3 in.), 82 ft. deep, through Boulder Clay, 67 ft., coarse Glacial sand passing into fine sand, 15 ft., with clay at the bottom ; water-level 48 ft. down ; supply good. January, 1904.

Made by, and information from, Messrs. Duke and Ockenden.

Laurence's Farm. Well (in yard by back door), 46 ft. deep, water-level 9 ft. down ; supply " very good ". In this upper part of Wibtoft water is found at about 50 ft. down. Information from Mr. J. A. L. Beasley, Leicester.

Clarke's House. Boring (diameter 5 in.), 54 ft. deep, through Boulder Clay with large and small stones, 50 ft., into (for 4 ft.) " running sand [Glacial] " ; water-level, 28 ft. down ; supply good. Information from Mr. J. A. L. Beasley, Leicester.

Nuneaton Rural District

The geology of the Nuneaton Rural District is shown on the Geological Survey map, New Series, Sheet 169, and the arrangement of the rocks along a line from Hinckley to Arley by a section accompanying that map.

Arley

" The Arley Colliery Company, Ltd.—Supplies part of the parish of Arley . . .

" Sources of Supply.—(1) Arley Bourne Brook, (2) Well, 114 feet, at Arley Colliery. The average daily quantity of water derived from each source is, respectively, (1) 240,000 gallons, (2) 144,000 gallons.

" Quantity of Water supplied.—The daily average is 3,500 gallons. Supply is constant.

" Quality of Water.—Very good."[1]

Analysis of water from Arley Colliery.—Communicated by E. C. Knox to F. C. Cook, formerly Borough Surveyor, Nuneaton, on 17.9.09. ?Parts per 100,000.

Carbonate of lime	79·60
Carbonate of magnesia	17·71
Peroxide of iron	·30
Alumina...	1·70
Sulphuric acid	·19

Stretton Baskerville

No. 1 Borehole.—On right bank of River Anker half a mile west of Stretton Lodge. Site marked on 1-inch Geological Survey map, New Series, Sheet 169.

Made in 1896 and particulars communicated by Messrs. Thompson Bros., Dunfermline.

Height above O.D. ? 285 ft.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
Glacial (Boulder Clay with associated sand).	Surface soil...	3	0	3	0
	Sand	4	0	7	0
	Blue clay	39	0	46	0
	Sand and mud	24	0	70	0
	Clay, stones and loose marl ...	60	0	130	0
Keuper Marl (242 ft.).	Marl with thin beds of gypsum ...	242	0	372	0
Lower Keuper Sandstone (250 ft. 6 in.)	White sandstone	10	3	382	3
	Red marl and sandstone ribs ...	5	6	387	9
	Red sandstone	3	2	390	11
	Red marl and sandstone ribs ...	10	7	401	6
	Red sandstone	2	8	404	2
	White sandstone	23	0	427	2
	Red sandstone	13	0	440	2
	Grey sandstone	12	0	452	2
	Marl...		8	452	10
	Red sandstone	6	9	459	7
	Grey sandstone	3	7	463	2
	Fakes[2] and marl	9	5	472	7
	Hard grey sandstone	1	1	473	8
	Marl and sandstone	7	0	480	8
	Hard grey sandstone	2	2	482	10
	Marl	1	0	483	10
	Red sandstone	11	0	494	10

[1] Return as to Water Undertakings in England and Wales (1915), p. 330. *Local Gov. Bd.*

[2] A Scotch miners' term for thin courses of sandstone.

		Thickness Ft.	In.	Depth Ft.	In.
Lower Keuper Sandstone (250 ft. 6 in.)	Conglomerate	3	0	497	10
	Marl...	15	4	513	2
	Red sandstone and marl beds ...	14	2	527	4
	Coarse red sandstone	21	5	548	9
	Red marl and fakes	9	9	558	6
	Soft sandstone	23	0	581	6
	Marl and sandstone	24	6	606	0
	Conglomerate	16	6	622	6
[?Pre-Cambrian.]	Igneous rocks	58	6	681	0

Rugby Rural District

The portion of this Rural District roughly to the west of a line joining Long Itchington-Birdingbury-Princethorpe-(near) Willey, is on Keuper Marl: to the east on Lower Lias. Locally, deposits—often comparatively thick (up to, say, 210 ft.)—of gravel, sand, and boulder-clay occur on the surface of the Marl and Lower Lias.

In the Keuper Marl country several borings have been made which have proved its thickness—the Brandon Boring, 277 ft.; Coombe Abbey Boring, 180 ft.; and Priory Hill Boring, Wolston, 434 ft. 6 in. All three borings penetrated the subjacent Lower Keuper Sandstone, and in all three the water obtained was unsuitable for use—in two cases too hard; in one case too salty.

In the Lias country two deep borings have been made: in the Urban District of Rugby, which is, however, surrounded by the Rural District. The 'Rugby Boring' (see also p. 95) revealed:—

	Feet.
Drift	10
Lower Lias	430
? Rhaetic	28
Keuper Marl	677
Lower Keuper Sandstone	(touched)
Total	1,145

At 1,140 ft. water rose in the borehole, but was found to be so impregnated with salt and gypsum as to be useless.

The other borehole at The British Thomson-Houston Company's Works ends 400 ft. down in the Keuper Marl: the supply is only 360 gallons per 24 hours, is said to be derived mainly from the Rhaetic, and "Owing to its content of Sodium Sulphate, it is slightly aperient, and if it was met with in quantity, would prove a very good mineral water." (See p. 96).

Borings of such a depth in search of water in the Rural District are not to be recommended.

The sands and gravels of the Superficial Deposits contain water. Many wells are sunk therein, and certain springs issuing therefrom

are made use of. The only way of obtaining *large* supplies within the district would be by impounding surface-water, as has been done for the supply of Rugby.

Birdingbury

Birdingbury Hall Boring. In the court-yard of Birdingbury Hall. Made about 1879 and particulars communicated by Messrs. LeGrand, Sutcliff and Gell, Ltd.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
	Dug well			8	0
	Boring :—				
Lower Lias [and Rhaetic[1]]	Top ground	2	0	10	0
	Loam	3	6	13	6
	Blue stone		4	13	10
	Loam	1	3	15	1
	Blue stone		4	15	5
	Loam	1	7	17	0
	Blue stone		5	17	5
	Loam	2	1	19	6
	Blue stone		6	20	0
	Loam	1	0	21	0
	Blue stone	1	3	22	3
[Keuper Marl]	Coloured clay		9	23	0
	Blue stone	1	0	24	0
	Coloured clay	1	0	25	0
	Blue stone		11	25	11
	Coloured clay	1	1	27	0
	Blue stone and blue clay in layers about 6 in. thick	21	3	48	3

Rest-level, 28 ft. 6 in. below the surface. This well is not now utilized ; but the original well of the Hall is in use.

Brandon and Bretford

Brandon Boring. Trial boring for water made in 1896 by Messrs. E. Timmins and Sons, Ltd., for the L. & N.W.R.Co. (L.M. & S.) on the north side of the railway in the cutting about half-way between bridges 304 and 305. " Site now indicated by a peg above and on the Coventry side of Brandon Wood Farm " (L. M. Withers). W. Andrews, *Proc. Warwickshire Nat. and Arch. F. C.* for 1897, pp. 33, 34 ; for 1906, pp. 10, 11. *Final Rep. Roy. Comm. Coal Supplies*, pt. ix, Appendix iv. ' Coventry Memoir,' p. 96.

Boring 10 in. in diameter :—

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Drift]	Soil	2	6	2	6
	Gravel	18	6	21	0
[Keuper]	Keuper Marl	277	0	298	0
[L.K. Sandstone]	Water Stone	36	0	334	0
[Coal Measures]	Broken Ground	6	0	340	0
	Black shale	5	0	345	0
	Blue shale	21	3	366	3

[1] The classification is only approximate.

Hardness of water.—Temporary, 30.1° (Clark); permanent, 94·5°—total, 124·6°. (Note by C. E. de Rance). Water not used: ? too hard for boiler-feed.

Andrews said :—" The boring was made by the jumping chisel, and not by diamond drill; consequently only fragments of rock were brought to the surface instead of cores, but the lower 26 feet are undoubtedly coal measures. There were one or more coal seams about an inch thick."

About 31 houses in Brandon village are supplied by an undertaking belonging to Capt. D. C. M. Beech from a well situate half-a-mile east-north-eastward of the railway station, the water from which is raised by a windpump to a reservoir in the village. The well is about 31 ft. deep in gravel and sand of an Avonside river-terrace.

Clifton-upon-Dunsmore

Lodge Farm Boring. Made in 1874.

J. M. Wilson, *Rep. Rugby School Nat. Hist. Soc.* for 1874, p. 52.

		Thickness Ft.	Depth Ft.
[Lower Lias]	Yellow clay	2	2
	Blue Lias clay	26	28
	'Sludge'	2	30
	Blue Lias clay	30	60
	Shaly rock	1	61
	Blue Lias clay	40	101

Wilson observed :—" It may be noticed that from the stratum called 'sludge' came a steady flow of water strongly impregnated with sulphuretted hydrogen."

Clifton Boring. Boring made by Messrs. LeGrand, Sutcliff and Gell, Ltd., but the precise site has been lost sight of, " the well now in use being only 6 to 12 ft. deep " (L. M. Withers). *Rep. Brit. Assoc.* for 1881, pp. 313, 314.

		Thickness Ft.	Depth Ft.
[Drift]	Sand	3	3
[Lower Lias]	Blue clay	19½	22½
	Clay and sand[1]	2½	25
	Light blue clay	7	32
	Dark blue clay	37	69
	Clay and sand[1]	5	74
	Light blue clay and sand[1] ...	4	78
	Light blue clay	27	105
	Dark blue clay	19	124
	Clay and sand[1]	4	128
	Dark clay	4	132

Combefields

Coombe Abbey Boring. Site marked on one-inch Geological Survey map, New Series, Sheet 169. W. Andrews, *Proc. Warwickshire Nat. and Arch. F. C.* for 1897, p. 33. 'Coventry Memoir,' pp. 96, 125. Height above O.D. 250 ft.

[1] By 'sand' is probably meant soft limestone. The term is known to have been used in this sense in Gloucestershire.

	Thickness Ft.	Depth Ft.
Keuper Marl	180	180
Keuper Sandstone	75	255
? Keele Beds	25	280

Water-level (rest).—Surface. Andrews said :—" The identity of the lower 25 feet is doubtful : it is probably Permian or coal measure.

" A small quantity of water was tapped in the white sand [Keuper Sandstone], and rose to the surface, but was so hard as to be useless."

According to L. M. Withers, Sanitary Inspector, Rugby Rural District Council, " Salt water was met with. The borehole has never been used and the water runs to waste."

In the Abbey grounds is a windpump and engine. According to W. T. Denyer and Sons, Brinklow, " The windpump and engine pump water from a pool near the gardens, which is supplied by the River Smite, up to a reservoir near High Lodge. The water then passes through a sand filter and is conveyed to the Abbey in pipes by gravitation.

" There is also a well and hand-pump near the cellar under the Abbey which supplies water strictly for drinking purposes."

Grandborough

Manor House Boring. According to Mr. L. M. Withers " A boring, about 240 feet deep [in Lower Lias], was made for Col. T. S. G. H. Robertson-Aikman, of the Manor House, some years ago, but the little water obtained was found to be unsuitable, and the borehole was abandoned."

Hillmorton

Rainsbrook Boring. Made in 1914 by Messrs. E. Timmins and Sons, Ltd., Runcorn, for Dr. H. Nelson Harness. The precise site is in the greenhouse on the premises of Rainsbrook near the twentieth milestone from Northampton on the Northampton-Dunchurch road (one-inch Geological Survey map, Old Series, 53 N.E.). L. Richardson, *Proc. Cotteswold Nat. F. C.*, vol. xxi, pt. i, for 1921 (1922), pp. 49-51.

	Thickness Ft.	In.	Depth Ft.	In.
Drift. Red sand and gravel	10	0	10	0
Lower Lias. Clays and limestones ...	440	1	450	1

The boring was abandoned as no water was found.

Kings Newnham

Newnham Regis Mineral Water. The site where these Mineral Waters occur is about 2½ miles north-west by west of Rugby. Attention was drawn to the water or " the spring was discovered " in 1579.[1]

[1] *Gentleman's Magazine* (1825), pt. i, p. 36.

Dr. Walter Bailey, in ' A Briefe Discours of certain Bathes or Medicinal Waters in the Countie of Warwicke, neere unto a village called Newnam Regis,'[1] published in 1582, gave instances of the curative value of these waters. He examined the water and came to the conclusion that while the solid left on evaporation tasted like salt it was probably nitre. Camden in his ' Britannia,' vol. 2 (1586), p. 336, quotes Bailey as to the discovery of the waters.

In 1817, in a compilation entitled ' Warwickshire ' embodying the more interesting portions of Sir William Dugdale's ' Antiquities of Warwickshire, (p. 177), the Bath is again mentioned. ". . . The water passes, in its course to the bath (in which it is extremely cold), through a lime pit.—It is considered a weak chalybeate." In 1857 the Bath was restored by Lord John Scott. In 1893 the Rev. W. O. Wait said (p. 247) in his ' Rugby Past and Present ' : —" A little distance from the village [of King's Newnham], on the road to Little Lawford, is a small cottage containing an old bath. This place was long known as ' the Wells ' . . ."

Princethorpe

St. Mary's Priory, some cottages, and a farm are supplied from shallow-seated springs issuing from a sprinkling of drift (gravel and sand) resting on Keuper Marl in a field on the south-west side of the road opposite Bull and Butcher Farm—half a mile north of the Priory.

Land springs from drift on marl in the wood five-eighths of a mile west of the Priory are piped to supply Wood Farm.

Stretton-on-Dunsmore

This village is for the most part built on drift (gravel—composed of Bunter pebbles, flints, etc.—which is worked in a pit in the village—and brown sand) resting on Keuper Marl. A number of springs issue from the drift in the north-eastern portion of the village, which is known as Well Head. Well Head is a spring five-sixteenths of a mile east-north-east of the church. According to L. M. Withers, Sanitary Inspector, Rugby Rural District, it is the best spring in his district. From a spring in a field near by water is pumped to the Manor House.

Willoughby

Mineral Waters. In 1828 there were two bathing establishments in this village—Willoughby Lodge Spa, in the fields about one mile from the high road ; and the Willoughby New Sulphureous and Saline Baths, situate on the high road opposite the Four Crosses. The ' springs ' of both establishments were waters tapped by wells in the Lower Lias.

[1] 8vo, *London.*

Willoughby Lodge Spa was mentioned by T. Deacon in 1828.[1] Dr. A. B. Granville, F.R.S., visited the Spa about 1841 and said[2] :— " The water stands at a depth of fifty feet from the surface, to which level it has been known to remain constantly, even on the days in which more than twenty baths had been served. The original borings, which were made in search of potable water, extended to 100 feet without detecting any, but two feet beyond that, the mineral water burst forth, and ascended to the pre-stated level." Granville's impression was that the water was a genuine sulphuretted saline.

' Willoughby Lodge Spa ' is now Willoughby House. The well is in the stable-yard and water is still pumped from it, but only for cleaning purposes.

Willoughby New Sulphureous and Saline Baths. The Baths were opened in the season of 1827. In 1828 T. Deacon published an interesting account of the waters,[3] including the following report on an analysis by M. Faraday, F.R.S., Professor of Chemistry to the Royal Institution :

Royal Institution, Albemarle Street, London.

June 24th, 1827.

Sir,

I have carefully examined the character of the water left with me from you ; its most distinguishing feature is the quantity of sulphuretted hydrogen gas dissolved in it ; but with this there is also present a large proportion of saline matter, containing, amongst other substances, a small quantity of carbonate of iron. The gases contained in the water are sulphuretted hydrogen and carbonic acid, with a trace of nitrogen. These salts are, first, muriate of soda, then sulphate of soda ; these forming by far the largest proportion of the saline matter present. Sulphate of lime is next in abundance ; the water appears to be nearly saturated with it, but it is not an abundantly soluble salt. There is also a minute trace of muriate of magnesia, a small quantity of carbonate of lime, and a trace of carbonate of soda. There is no free sulphur in the fresh water, but, if it be left exposed to air, sulphur is deposited in it in consequence of the decomposition of the sulphuretted hydrogen by the oxygen of the air. I have not analysed the Harrowgate water myself, and therefore can only speak generally of its similarity with that you sent me. Its resemblance in the most striking ingredient, i.e., sulphuretted hydrogen, is evident on the slightest observation.

(Signed) M. FARADAY.

To Mr. W. Crupper,
New Baths, Willoughby.

No traces of these Baths by the ' Four Crosses ' now remain, nor of the building. The probable site is covered by three cottages, under the floor of one of which—but built over—is said to be the ' Baths Well.'

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[1] ' History of Willoughby with an Account of the Mineral Waters' (1828), p. 62.

[2] ' The Spas of England, etc. Midland Spas ' (1841), p. 139 *et seq.*

[3] ' History of Willoughby with an Account of the Mineral Waters ' (1828), pp. 48-62.

Wolston

PRIORY HILL BORING.—To supply Priory Hill. The water from the borehole is not now used owing to its excessive hardness. Made about 1910 and communicated by Messrs. C. Isler and Co., Ltd.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Drift]	Soil	2	0	2	0
	Sand and Gravel	5	0	7	0
	Ballast	9	0	16	0
	Sandy loam	9	0	25	0
	Hard combined gravel	3	6	28	6
	Sandy shale	1	0	29	6
[Keuper Marl]	Red marl	34	0	63	6
	Marlstone	1	0	64	6
	Hard shale	6	3	70	9
	Shale	1	3	72	0
	Marl	1	6	73	6
	Stone	2	0	75	6
	Shale	2	9	78	3
	Stone		9	79	0
	Marl	6	3	85	3
	Red stone	7	0	92	3
	Greenish stone	1	9	94	0
	Very hard stone	2	0	96	0
	Stone	2	0	98	0
	Greenish marl	1	9	99	9
	Red marl	5	7	105	4
	Hard shale	9	2	114	6
	Marl	3	0	117	6
	Hard shale	11	0	128	6
	Shale	5	6	134	0
	Marl	3	6	137	6
	Shale	2	6	140	0
	Green and red shale	3	9	143	9
	Hard shale	5	0	148	9
	Marl	4	0	152	9
	Shale (with a little water)	11	0	163	9
	Marl	4	0	167	9
	Shale	5	3	173	0
	Hard shale	19	9	192	9
	Marl (little water)	3	0	195	9
	Hard shale (little gypsum)	43	3	239	0
	Gypsum (?)		3	239	3
	Hard shale	9	6	248	9
	Rock	1	6	250	3
	Hard shale and gypsum	2	0	252	3
	Hard shale	10	0	262	3
	Gypsum and shale	16	0	278	3
	Shale	13	0	291	3
	Green shale	1	6	292	9
	Shale	12	0	304	9
	Gypsum		6	305	3
	Shale	6	0	311	3
	Marl	2	0	313	3
	Hard shale and gypsum	6	0	319	3
	Shale	34	0	353	3
	Marl	6	9	360	0

		Thickness Ft.	In.	Depth Ft.	In.
[Keuper Marl]	Gypsum		4	360	4
	Shale	31	8	392	0
	Veins of gypsum		2	392	2
	Shale	3	7	395	9
	Variegated shale	10	6	406	3
	Gypsum		6	406	9
	Green shale		9	407	6
	Variegated shale, hard	2	3	409	9
	Hard shale and gypsum	11	0	420	9
	Hard red and green marl ...	3	3	424	0
	Shale and gypsum...	34	0	458	0
	Gypsum	6	0	464	0
[Lower Keuper Sandstone]	Red and green sandstone... ...	11	6	475	6
	Sandstone	74	6	550	0

Water-level.—Overflowed whilst boring. 43 ft. ex surface when pumping.

ANALYSES, RUGBY RURAL DISTRICT.

Made by Messrs. Bostock Hill and Rigby, Birmingham.

1. Bourton-on-Dunsmore. Well, in village, 15 ft. deep.
2. Ryton-on-Dunsmore. ,, ,, ,, 30 ft. ,,
3. Brinklow. ,, ,, ,, 24 ft. ,,
4. Willoughby. ,, Manor House.
5. Flecknoe, Wolfhamcote ,, at Vicarage, 30 ft. ,,
6. Dunchurch. ,, at Bilton Grange (gardener's cottage).
7. Thurlaston. ,, at Chapel of Ease near Thornhall Wood.
8. Brandon. ,, (new), in village.
9. Leamington Hastings. ,, at Post Office, 15 to 30 ft. deep.

In parts per 100,000.

	1	2	3	4	5	6	7	8	9
Date of receipt of sample ...	1.8.23	16.9.24	20.7.23	20.7.23	27.2.24	1.3.24	7.3.24	15.1.23	3.6.24
Free and saline ammonia ...	trace	0·0005	0·002	0·001	0·0015	0·001	0·002	0·002	0·0015
Albuminoid ammonia	0·008	0·006	0·012	0·010	0·016	0·014	0·024	0·012	0·020
Chlorine in chlorides	8·850	3·000	2·300	3·900	2·900	4·100	7·450	2·600	7·500
Nitrogen in nitrates and nitrites	0·660	1·100	0·330	1·210	trace	0·770	4·950	0·220	2·750
Oxygen absorbed from permanganate at 80°F. in 4 hours ...	0·058	0·025	0·139	0·043	0·149	0·050	0·166	0·160	0·239
Total solids dried at 100°C. ...	88	45	92	70	36	56	130	74	111
Appearance	Bright, many small particles	Bright, many small particles	Turbid, very many small particles	Bright, few small particles	Bright, many small particles	Bright, few small particles	Bright, few small particles	Slightly turbid, many small particles	Bright, many small particles
Remarks	Reasonably safe	Reasonably safe	Unsafe	Unsafe	Not quite satisfactory	Not quite satisfactory	Unfit for drinking purposes	Not quite satisfactory	Unsafe

Solihull Rural District

The Solihull Rural District is on Keuper Marl[1] on the surface of which are extensive spreads of Superficial Deposits. These Superficial Deposits consist of Boulder Clay, sand, and gravel (all Glacial), with locally river-terrace gravels, and, alongside the brooks, Alluvium.

Where the site of a well is on Superficial Deposits, little additional water will be obtained by continuing into the Marl; and where it is on the Marl experience indicates that it is inadvisable to go deep. A boring made at The Homestead, Chessetts Wood, Knowle, in 1911, 150 ft. deep, and 6 in. in diameter, to supply the house is said to have been successful: on the other hand, one 128 ft. deep, at Earlswood, Tanworth, gave no supply. If the Lower Keuper Sandstone were reached the water would probably be very hard and liable to be salty.

Springs, mostly from the Superficial Deposits, are numerous but small. Water from one at Berry Hall, Solihull, is raised by ram to supply the Hall, and is said to be "reasonably soft": another in Tanworth village is made use of by those dwelling in the vicinity.

The mains of the Birmingham Corporation Waterworks are available for practically the whole of the populous parts of Solihull, Shirley, and Olton; while Knowle and Temple Balsall also receive Birmingham water through the mains of what was, until 21 September, 1921 (when it was taken over by the Coventry T. C.), the North Warwickshire Water Company.

Otherwise the District is dependent on wells (say 15 to 90 ft. deep), mostly shallow—the majority in the Superficial Deposits. On the whole the supplies are adequate and satisfactory as regards quality.

Temple Balsall

According to F. W. Shotton, "a chalybeate spring issues from sand (Drift) on Keuper Marl at 630 yards north-north-east of Holly Grange. The spring rises in the middle of a field, is piped for about 50 yards, comes out at the edge of the field, and flows 100 yards south to join a stream that flows north-west across Balsall Common. The open end of the pipe and the ground around it becomes covered with masses of iron hydroxide, necessitating cleaning every six months." (F.W.S. 8.8.1927).

Analyses.

1. Solihull and Meriden Joint Isolation Hospital, Catherine de Barnes. Well, 50 ft. ('Running sand' Superficial Deposits, 25-30 ft.: Keuper Marl, 25 ft. to 20).

2 and 3. Tidbury Green, Low Brook, Shirley, Solihull parish. Well, 20 ft. (Keuper Marl).

Analysis by Messrs. Bostock Hill & Rigby, Birmingham.

[1] Near Knowle village, resting on the Keuper Marl, is a small outlier of Rhaetic and Lower Lias.

	In parts per 100,000.		
	1	2	3
Free and saline ammonia...	trace	0·002	trace
Albuminoid ammonia	0·008	0·010	0·008
Chlorine in chlorides	3·200	0·900	0·800
Nitrogen in nitrates and nitrites... ...	0·990	trace	0·110
Oxygen absorbed from permanganate at 80°F. in 4 hours	0·011	0·053	0·175
Total solids dried at 100°C.	56	34	17

Particulars of some wells in the Solihull Rural District. Sunk in Keuper Marl with or without a covering of Drift.

Site	Depth of well or borehole (in feet)	Remarks
Elmdon Rectory	80	
Knowle, The Homestead, Chessetts Wood	150 (6in. dia.)	Successful Keuper Marl
Lapworth, Yew Tree Cottage ...	140 (5in. dia.)	
Packwood Schools	80	
,, Hall	25	
Solihull, Tidbury Green, Low Brook	20	Keuper Marl
Solihull and Meriden Joint Isolation Hospital	50	Sand 25 to 30ft. Keuper Marl 25 to 20 ft.
Tanworth, The Bungalow ...	200	28 ft. of water
,, Earlswood	128	No supply
,, Hockley Heath House	180	No supply

Southam Rural District

By far the greater part of this Rural District is on the Lower Lias. The escarpment of the relatively thin Rhaetic Series, which separates the Lower Lias from the Keuper Marl, runs through the parishes of Lighthorne, Chesterton, and Kingston, Harbury, Ufton, and Long Itchington, and, therefore, Keuper Marl occurs in these parishes to the west (roughly) of the escarpment.

The Lower Lias comprises alternating layers of limestone and shale or clay in, say, the lower third, and clay, almost entirely, in, say, the upper two-thirds. It is a notoriously bad source of water : such little as may be found is usually hard, not infrequently salty—as evidenced by a pool on Manor House Farm, Knightcote, Burton Dassett ; ' Salt Spring ', near Southam Holt, Southam ; and the water obtained by a boring at Hodnell (p. 60), and locally, may be impregnated with sulphuretted hydrogen.

At Harbury Hall, close to the escarpment of the basal beds of the formation, a thickness of 154 ft. of Lias was proved : at Hodnell a boring some 200 feet deep is said to go through the clays into the upper limestones of the lower division.

The Middle Lias consists of Sandy Beds succeeded by Marlstone. Locally, useful springs issue from at or near the base of the Sandy

Beds, and certain are taken for the supply of North End and Knightcote in Burton Dassett parish, Fenny Compton, Lower Shuckburgh, Napton-on-the-Hill, Priors Hardwick, and Priors Marston.

Burton Dassett

KNIGHTCOTE.[1] This hamlet is supplied from a spring issuing from at or near the base of the Sandy Beds of the Middle Lias some 400 yards south-east by east of the church at Northend. The water is collected into a reservoir, of about 21,805 gallons capacity, from which it is piped to a stand-pipe. Analysis, p. 64.

NORTHEND.[1]—This hamlet is supplied from springs issuing from the same geological horizon as that supplying Knightcote situate 550 yards south-south-east of the Church at Northend. There are two reservoirs of about 18,316 and 13,456 gallons capacity respectively. Analysis, p. 64.

Fenny Compton

FENNY COMPTON WATERWORKS CO., LTD. The source of supply is Tight Head Spring—a spring issuing from the same geological horizon as those supplying Knightcote and Northend. The water is conveyed into a reservoir of 8,000 gallons capacity (situate in a field on the west side of the road about half way between the village and Fenny Compton Hill) from which it is piped to the village and laid on in 65 houses and to standpipes. Analysis, p. 64.

A spring from a limestone bed, 1 ft. thick, in Lower Lias shales (of *jamesoni* or early *valdani* hemera), exposed in the cutting of the East and West Junction Railway (now the London, Midland & Scottish Rly.) south-east of Fenny Compton Station, proved to be medicinal.

Analysis made by T. Beesley and published in *Proc. Warwickshire Nat. and Arch. F. C.* for 1877 (1878), p. 9.

Chloride of potassium	1·05
,, ,, sodium	14·08
Sulphate of soda	55·44
Carbonate ,, ,, ...	31·16
Carbonates of lime and magnesia ...	2·20
Total ...	103·93

Gaydon

This village is supplied by an undertaking belonging to the Southam R.D.C. from a spring situate some 330 yards north-west by north of the Church. There is a reservoir of about 2,242 gallons capacity. Analysis, p. 64.

[1] Some inhabitants say that both these supplies were carried out by Kimbell's Charity.

Harbury

HARBURY HALL BORING. Site some 250 yards east of the Church. Made by percussion in 1905 and communicated by Messrs. H. Brown & Co., of Bristol. Height above O.D. about 390 ft.

	Boring (8 in. diameter) :—	Thickness Ft.	Depth Ft.
	1. Top soil	2	2
[Lower Lias]	2. Blue shale and layers of rock	48	50
	3. Blue rock	6	56
	4. Blue shale	50	106
[Rhaetic and	5. Layer of dark blue rock ...	8	114
? Tea-green	6. Light blue shale	40	154
Marls]	7. Green and red marl ...	20	174
	8. Light rock (almost white)	5	179
	9. Green marl	2	181
	10. Red marl and gypsum ...	178	359
[Keuper	11. Conglomerate	8	367
Marl]	12. Hard red marl and sandstone rock [? Arden Sandstone]	33	400
	13. Red marl rock	40	440

Result.—Abandoned : practically no yield. With regard to this record, it may be suggested that, bed 5 is White Lias ; bed 6, Rhaetic black shales ? *plus* Tea-green Marls (Keuper) ; and the sandstone in bed 12, the Arden Sandstone.

Hodnell

HODNELL BORING. A boring made here 200 feet deep is said to have reached the hard limestone-bands of the lower division of the Lower Lias ; but while—it is stated—a fair amount of water was obtained, it was so salty that it could not be used except for rough washing purposes.

Lighthorne

This village is supplied by the Rural District Council who have piped spring-water to two pumps.

Lower Shuckburgh

This village is supplied by an undertaking belonging to the Southam R.D.C. from a spring issuing from either the *Capricornus* Beds of the Lower Lias or the base of the Sandy Beds of the Middle Lias a quarter of a mile west of Upper Shuckburgh Church. The water is collected into a reservoir of about 700 gallons capacity from which it is piped to two standpipes in Lower Shuckburgh village. The supply runs low at times. Analysis, p. 64.

Napton-on-the-Hill

There are two piped supplies here : both derived from springs issuing from the base of the Sandy Beds of the Middle Lias. The spring supplying the village is situate about 250 yards south-west by west of the Church. The reservoir is of about 10,000 gallons

capacity. Analysis, p. 64. The spring supplying the 'North Side' (or 'Daventry Road')[1] is situate about 500 yards north-north-west of the Church. The reservoir is of about 2,500 gallons capacity from which the water gravitates to a stand-pipe and cattle-trough.

Priors Hardwick

HARDWICK HOUSE BORINGS. Made in 1923 and communicated by Messrs. LeGrand, Sutcliff and Gell, Ltd. No. 1 Bore, just south of 'Fox Covert.' Surface-level, about 470 ft. above O.D.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
	Existing pit	31	6	31	6
[? Top portion of Lower Lias— ? *Capricornus*-Zone]	Blue marl	28	0	59	6
	Blue marl and broken pieces of rock	8	6	68	0
	Blue marl	32	0	100	0

Rest-level, 12 ft. 6 in. ex surface. Yield, about 60 gallons per hour. Boring finished 12th February, 1923, but abandoned owing to insufficient supply.

No. 2 Bore, just north of 'Fox Covert.' Surface-level, 450 ft. above O.D.

		Thickness Ft.	Depth Ft.
	Loamy soil	2	2
[? Top portion of Lower Lias— ? *Capricornus*-Zone]	Brown clay	10	12
	Blue marly clay...	13	25
	Blue marl	37	62
	Tough blue marlstone	8	70

Rest-level, 14 ft. 6 in. ex surface. Yield, about 60 gallons per hour. Boring finished 1st May, 1923, but abandoned owing to insufficient supply.

PRIORS HARDWICK WATER CO., LTD. The source of this Company's supply is a good spring issuing from either the *Capricornus* Beds or the base of the Sandy Beds on the east side of the road some 550 yards south-westward of the Church.

Priors Marston

PRIORS MARSTON WATER CO., LTD. This Company's sources of supply are two springs—(1) from the Middle Lias three-quarters of a mile east of the Church, and (2) five-eighths of a mile slightly west of north of the Church.

Southam and Long Itchington

SOUTHAM WATERWORKS. The well and Pumping Station of this undertaking, which belongs to the Southam R.D.C., are located at Holy Well, Southam (see pp. 18 and 62). The water is pumped to a reservoir of 250,000 gallons capacity on the high ground near the Stockton road, from which it gravitates to the country town of Southam and the village of Long Itchington.

[1] Provided in 1898.

Southam

Holy Well. This spring is situate about half-a-mile westward of Southam Church. It is probable that the water maintaining it issues from the Rhaetic White Lias.

J. Beck, in the fourteenth edition [1870] of his Leamington Guide, p. 77, said that the spring was ". . . of considerable antiquity, remarkable for its extreme coldness" : W. G. Fretton (*Proc. Warwickshire Nat. and Arch. F. C.*, for 1890, p. 33), that it was ". . . a powerful spring, formerly better valued than now, for some monks who had a cell here in the 14th century enclosed it with stonework, which is still in existence though much mutilated."

The well is in a semicircular recess in the bank. A low retaining wall—recently renovated—prevents the bank from slipping down into it. At its foot is a flagged path along the curved margin of the semicircular well. Impounding the water in the well—along what would be the diameter if the well were circular in plan—is low two-buttressed stonework. The stonework is much mutilated, the water flowing over the two broken and worn ends ; but the central portion is higher and has three faces sculptured on it from orifices below which the water spouts out. Two flights of steps—that on the left with three steps, that on the right with four—lead down to a ' trough ' below the stonework out of which the water is conveyed, underground, into the brook called Watergall—a tributary of the River Itchen.

Sixth Report (1874) *Rivers Pollution Commission*, p. 127.

Analysis.—	Parts per 100,000.
Total solid impurity	71·90
Organic carbon	·164
Organic nitrogen	·028
Ammonia	·006
Nitrogen as nitrates and nitrites	·217
Total combined nitrogen	·250
Previous sewage or animal contamination	1,900
Chlorine	2·50
Hardness : Temporary	24·4
Permanent	18·4
Total	42·8
Remarks	Slightly turbid. Palatable.

Southam Waterworks. A few yards to the north of Holy Well is the Pumping Station of the Southam Waterworks (Southam R.D.C.). A little to the northward of the actual Station is the Council's well which taps the same source of supply as maintains the Holywell spring.

The Council's well was sunk in May-July, 1914, but the War and delay in obtaining electric power prevented the scheme from being completed until 1925.

Surface-level, 268 ft. above O.D. Well (Internal diameter 6 ft. by 6 ft.) :—

		Thickness Ft.	In.	Depth Ft.	In.
	Turf and top soil	1	6	1	6
[Lower Lias.]	Clay	19	6	21	0
[Upper Rhaetic]	Yellow rock (water-bearing) ...	8	0	29	0
	Clay (sump in)	5	0	34	0

Water-level.—At commencement of pumping, 23 ft. ex surface. At cessation of pumping, 27 ft. ex surface.

Yield, 106,000 (minimum) to 215,000 (maximum) gallons during 23 days pumping-test from 27th June to 19th July, 1914: pumping average, 148,000 gallons per day.

The 'yellow rock' is probably White Lias; the 'clay', in which is the sump, the Cotham Beds.

Ivy House Boring. ? Lower Lias only ... 70 ft.

At first the water was unsuitable for potable purposes on account of excessive total solids, but improved after a while.

Ufton

Spring water, probably from the Rhaetic White Lias, is run into a brick reservoir (alongside the main road below the Church) from which some water gravitates to supply two cottages below, and some is pumped, at a little pumping-station in the field on the south side of the road, to Home Farm. The undertaking belongs to Balliol College, Oxford.

ANALYSES, SOUTHAM RURAL DISTRICT
Made by F. Thompson, Public Analyst, Walsall.

	Reference	Sample taken from	Date on which sample was taken	In parts of per 100,000						Remarks
				Total solids	Amm. Nitrogen.	Album. Nitrogen.	Nitric Nitrogen.	Combined Chlorine.	Oxygen	
Burton Dassett :										
Knightcote Supply ...	p. 59.	Standpipe	8.7.14	72·9	·001	·002	trace	1·8	·03	Fit for drinking purposes.
Northend Supply ...	p. 59.	Do.	Do.	20·8	none	·003	·22	1·8	·027	
Fenny Compton :										
Fenny Compton Waterworks Co., Ltd.	p. 59.	Do.		41·3	·4	·005	·02	2·0	·092	
Gaydon	p. 59.	Do.	8.7.14	125·0	·048	·01	trace	4·2	·13	
Lower Shuckburgh	p. 60.	Do.	29.10.15	44·5	·006	·0025	·32	4·1	·05	
Napton-on-the-Hill Village Supply	p. 60.	Do.	4.9.15	62·0	nil	·002	·64	3·2	·042	
		Reservoir	30.8.21	39·0	·004	·003	·5	2·0	·09	
Priors Hardwick :										
Priors Hardwick Water Co., Ltd.	p. 61.	Standpipe	30.8.21	13·0	·008	·002	·20	1·5	·04	
Priors Marston :										
Priors Marston Water Co., Ltd.	p. 61.	Do.	13.9.15	31·0	nil	·003	trace	2·9	·34	
		Do.	Do.	30·5	nil	·0016	·29	2·2	·034	
Southam :										
Southam Waterworks (R.D.C.) Holy Well	p. 61.	Well	26.11.19	116·0	trace	·006	·110	5·2	·077	

Stratford-on-Avon Rural District

The geology of this Rural District has not yet been revised for the New Series Maps of the Geological Survey. Only the Old Series 'Solid' Maps, 53 S.W., 54 N.E., S.E., are available, on which the distribution of the Superficial Deposits is not shown. The geology, however, is simple: the District extends over the Keuper Marl and Lower Lias—between which is the thin Rhaetic Series; on the surface Superficial Deposits are locally distributed. The Keuper Marl is underlain by Lower Keuper Sandstone, which—so far as the information at present available goes—probably rests everywhere, unconformably, on the Enville Beds of the Upper Coal Measures. Proved thicknesses of the Keuper Marl and Lower Keuper Sandstone will be seen on reference to the particulars of strata penetrated by boreholes given in the following pages. The water in the lower Keuper Sandstone is hard and locally may be saline. The chief points that require watching in connexion with boreholes deriving supplies from the Keuper Sandstone are whether the rest-level of the water is maintained or has a downward tendency, and whether the chlorine content remains steady or rises—especially in cases where there is a falling rest-level. There is the possibility of the Sandstone being locally over-pumped owing to its being overlain by a thick covering of impermeable Keuper Marl and its outcrop being distant.

Keuper Marl country is readily recognised by the red nature of the ground: Lower Lias country by the grey, heavy-clay nature. Limestone-bands are of frequent occurrence in the lower portion of the Lower Lias: locally, from the outcrop of individual bands, small springs issue, and the bands also yield water when pierced by wells. But the supply is limited and, on boiling, much carbonate of lime is thrown out of the water. Saline waters are always likely to be encountered, especially in the higher clays, and water impregnated with sulphuretted hydrogen is occasionally struck. In other words, little water is obtainable from the Lower Lias, and such as is, is not as a rule good potable water.

On or near the outcrop of the Rhaetic Series, when supplies for limited requirements are desired, the White Lias should be investigated as a possible source. The Rhaetic Series is not shown on the Old Series Geological Survey Maps, but it outcrops between the Keuper and Lias. The White Lias is to be found displayed in places in the rear of the main escarpment, and locally is not deeply buried beneath the Lower Lias. The rock is readily recognisable: it is a whitish limestone with a splintery fracture and its identity is usually to be established by the occurrence of specimens of the fossil *Dimyodon*.

The distribution of the Superficial Deposits is not shown on the Old Series Maps, but there is no difficulty in recognising them. They consist of sand and gravel. The deposits are not thick, but locally small springs issue from them. Wells sunk in them collect water,

but the point to bear in mind is that they should be made in such positions and so constructed that their waters are immune from surface pollution.

Billesley

Billesley Manor and four other houses are supplied by an undertaking belonging to Captain H. B. Tate from a spring, the water of which is piped to a reservoir from which it gravitates to the houses supplied.

Binton

Four houses are supplied by an undertaking belonging to the Marquess of Hertford from a spring from gravel on Lower Lias clay a quarter of a mile to the west of the Church.

Binton Hill Trial Boring. This boring was made with a view to ascertaining whether a satisfactory water supply could be obtained should the site be selected for the King Edward VII Memorial Sanatorium. The boring was commenced in the Lower Lias and apparently did not penetrate it.

Dr. Hamilton Wood, County Medical Officer of Health, Warwickshire, informs me (*in lit.* 25th March, 1925) :—" I am afraid I cannot give you any very detailed information [concerning the boring]. From particulars in my possession, however, it would appear that a limited quantity of water was found at a depth of 30 feet, which was not appreciably saline ; but when they got down to approximately 150 feet, the water was reported as being quite unsuitable for drinking purposes, owing principally to its salinity."

Analysis communicated by Dr. A. Hamilton Wood, County Medical Officer of Health, Warwickshire.

	Parts per 100,000
Chlorine	24·7
Nitrogen as nitrates	50·3
Sulphuric acid	50·3
Carbonic acid	6·3
Lime	9·2
Magnesia	5·8
Oxide of iron and alumina	0·6
Silica	1·3
Soda	43·8
Total solids by evaporation	167·0
Ammonia	0·145
Albuminoid ammonia	0·009
Oxygen absorbed	0·07
Hardness : Temporary	18·7
Permanent	16·6
Total	35·3

The chief minerals present were Sulphate of Sodium and Chloride of Sodium.

Claverdon

CLAVERDON BORING. Bryn-Arden and a lodge are supplied by an undertaking belonging to Miss Mitchell of Bryn-Arden from a borehole (completed Sept. 18th, 1915) 823 ft. deep. The borehole is situate some 300 yards northward of the Church near the Scouts Hall. Commented upon by L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 286.

The water is pumped up from the borehole, and the pipe-line passes through the village of Claverdon.

Made and particulars communicated by Messrs. C. Isler & Co., Ltd.

Height above O.D. 420 ft.

		Thickness Ft.	Depth Ft.
[Drift]	Mould and pebbles	2	2
	Ballast	11	13
[Keuper Marl]	Red and blue marl with gypsum	763	776
[Lower Keuper Sandstone]	Sandstone	47	823

Lined with 152 ft. of tubes, 8 in. in diameter, top 1ft. 6 in. below surface. 730 ft. of tubes, 5 in. in diameter, top level with surface. Water-level (standing), 152 ft. below the surface.

Combrook

41 houses in Combrook, mostly in the village, and 4 in Compton Verney parish are supplied by an undertaking belonging to Lord Manton : the Rural District Council supervises, and work is carried out by the estate. The water is supplied rate free. The source of supply is a small spring (yield about 54 gallons per hour) issuing from limestone beds amid clays (Lower Lias) at about half a mile south-westward of Combrook Church. The water is collected and conveyed in agricultural pipes to a reservoir (4,000 gallons) on the hill side at the southern end of the village from which it is laid on to two old fountains and two standpipes.

Kineton

Kineton is supplied by an undertaking belonging to Lord Manton but leased to the Rural District Council. The sources of supply are two :—

(1) King John's Well[1] ; and

(2) Heading in Lower Lias from Low Level reservoir, Pittern Hill.

King John's Well was formerly a small dip well, but is now enclosed in a brick chamber. The flow is about 64 gallons per hour, but this yield is more than halved in dry weather—in August and September. Additional water was collected and piped into the chamber in 1921. The water comes from limestone beds amid clay (Lower Lias), and from the well is piped to a well at the little

[1] King John occasionally held his court at King John's Castle, Kineton.

pumping-station near by. From the pumping well the water is raised to the High Level Reservoir (15,000 gallons) on Pittern Hill. The overflow from this reservoir runs into the Low Level Reservoir (10,000 gallons) in the field below. From this Low Level Reservoir is an ' adit ' (open cut filled in with rubble) running as far as the old brick reservoir close to the High Level Reservoir : this ' adit ' also collects water coming from limestone bands amid clay (Lower Lias). Originally the yield of the ' adit ' was 3,500 gallons per day, but it has fallen off.

Loxley

52 out of the 59 houses in the parish, located in the village, are supplied by an undertaking installed by the late Mr. Jones. The undertaking was made over by his executors to the Rural District Council, and the water is supplied rate free. The source of supply consists of three small springs issuing from limestone beds amid clay (Lower Lias) about a quarter of a mile east-south-eastward of Loxley Church. The springs (yield 74 gallons per hour) are picked up by agricultural pipes and conveyed to a reservoir in the same field (as the springs). From the reservoir the water gravitates to five standpipes.

Moreton Morrell

MORETON MORRELL BORING. Half a mile south by 50° west of the Church, Moreton Morrell.

L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 302.

Made in 1911 and communicated by Messrs. E. Timmins & Sons, Ltd., Runcorn. Height above O.D. about 250 ft.

		Thickness Ft.	Depth Ft.
[Lower Lias & Rhaetic]	Surface soil and Lias clay [and Rhaetic beds]	53	53
[Keuper Marl]	Gypseous marls	474	527
	Sandy marls (' Passage Beds ')	17	544
[Lower Keuper Sandstone]	Grey Sandstone	101	645
[?Enville Group]	' Permian ' marl	2	647

Result.—Quantity and quality of water ' very satisfactory.'

MORETON PADDOX BORING. One and one sixteenth miles south by 7° west of the church, Moreton Morrell—in angle made by parish boundary south-east of Hell Hole.

L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 302.

Made in 1910 and communicated by Messrs. E. Timmins & Sons, Ltd. Height above O.D. about 300 ft.

		Thickness Ft.	Depth Ft.
[Lower Lias & Rhaetic]	Surface clay and Lias clay [and Rhaetic beds]...	44½	44½
[Keuper Marl]	Gypseous marls	470½	515
[L.K. Sandstone]	Grey sandstone	85	600

Result.—Quantity and quality of water ' very satisfactory '.

The water is pumped from the borehole to a water-tower from which Moreton Paddox and three or four lodges are supplied.

Snitterfield

13 out of 185 houses in the parish are supplied by an undertaking belonging to Lady Trevelyan from a spring from gravel, resting on Keuper Marl, situate about 660 yards south-south-westward of the Church. The water gravitates to a small tank at Snitterfield.

Wootton Wawen

In this parish are Henley-in-Arden and Ullenhall, both of which places have piped supplies belonging to the Stratford-on-Avon R.D.C. In all some 313 houses in the parish are so provided for.

The Henley-in-Arden Supply is at present[1] derived from two springs from gravel on Keuper Marl at (1) Forde Hall (about 3 miles north-westward of Henley-in-Arden) near Tamworth ; and (2) Liveridge Hill (about 2 miles north of Henley-in-Arden).

The water of (1) gravitates to a reservoir of 15,000 gallons capacity ; of (2) to one of 75,000 gallons capacity.

According to the Return as to Water Undertakings in England and Wales, 1915, Local Gov. Bd., p. 136, the average daily quantity of water available from the Forde Hall spring is 43,000 gallons ; hardness, 45°.

Beaudesert is supplied from the Henley-in-Arden Supply (mixed waters).

The Ullenhall Supply is derived from a spring from gravel on Keuper Marl situate half a mile north-north-east of Ullenhall church. The spring water is piped to a well from which it is raised by a wind-pump to a service reservoir (10,000 gallons) whence it gravitates to the village.

[1] It is proposed adding another spring and increasing the storage capacity at Forde Hall. There is an overflow from the existing reservoir of 18,036 gallons per 24 hours.

ANALYSES, STRATFORD-ON-AVON RURAL DISTRICT.

1. Bearley Public Well. 26.11.15.
2. Binton. Marquess of Hertford's Supply. 28.10.15.
3. Combrook. Lord Manton's Supply. 26.11.15.
4, 5. Hampton Lucy. 4. Snitterfield Road Well. 5. Church Well. 28.10.15.
6. Kineton Public Supply. 26.11.15.
7. Loxley Public Supply. 28.10.15.
8, 9, 10, 11. Wootton Wawen. Public Supply to Henley-in-Arden—(8) Forde Hall Spring. 26.7.17; (9) Liveridge Hill Spring. 28.10.15. Public Supply to Ullenhall (10) 26.11.15. (11) 26.7.17.

Analyses by Messrs. Bostock Hill & Rigby, Birmingham.

In Parts per 100,000.

	1	2	3	4	5	6	7	8	9	10	11
Free and saline ammonia	0	0	0	0	0	0	0	0	0	0	trace
Albuminoid ammonia...	0·010	0·007	0·010	0·016	0·016	0·006	0·005	0·003	0·007	0·008	0·004
Chlorine in chlorides	8·3	1·8	1·5	4·2	6·0	1·8	1·8	1·8	1·4	1·5	1·9
Nitrogen in nitrates and nitrites ...	3·52	0·22	0	0·22	5·4	0	0	trace	0·15	0	trace
Oxygen absorbed from permanganate at 80°F. in 4 hours	0·090	0·076	0·136	0·115	0·125	0·044	0·033	0·034	0·041	0·072	0·034
Total solids dried at 100°C.	116	107	43	68	147	78	46	45	46·5	44	46

Appearance :—

1, 10. Slightly turbid.
2. Slightly opalescent, containing a few large and many small particles.
3. Opalescent, containing many small particles.
4, 6. Bright, containing a small few particles.
5. Bright, containing a few large particles.
7, 9. Bright, containing many small particles.
8, 11. Bright and clear.

Remarks :—

1, 3, 6, 8-11. Safe for drinking purposes.

TAMWORTH (STAFFS.) RURAL DISTRICT

The geology of the Warwickshire parishes in this Rural District is shown on the Geological Survey maps, New Series, Sheets 154, 155, and a section across a portion of the District is given on Sheet 154.

Amington and Stonydelph

MOOR FARM BORING. On the river-gravel of the Anker, one mile north-east of Tamworth. Site shown on Geological Survey map, New Series, Sheet 154. Close to Moor Farm. Made for the Tamworth Board in 1875. Particulars communicated by H. J. Clarson, Town Surveyor, and published in the ' Lichfield Memoir,' p. 280 : see also pp. 150 and 224. Top nearly 200 ft. above O.D.

		Thickness		Depth	
		Ft.	In.	Ft.	In.
[River Deposit]	Soil	1	0	1	0
	Sand and gravel	6	6	7	6
	Clay	2	0	9	6
[Keuper Sandstone]	Strong grey rock	10	6	20	0
	Clay		3	20	3
	Strong grey rock	2	6	22	9
	Soft grey rock	3	3	26	0
	Marl		3	26	3
	Strong red stone	3	2	29	5
	Soft red stone	4	0	33	5
	Clay		4	33	9
	Strong grey rock	4	3	38	0
	Clay		3	38	3
	Strong red stone	4	6	42	9
	Soft red stone	7	0	49	9
	Clay		3	50	0
	Strong red stone	5	0	55	0
	Soft red stone	7	0	62	0
	Clay		3	62	3
	Strong red rock	19	9	82	0

The water was so saline as to be useless, but it is not known whether the soluble material was sodium chloride or not.

G. Barrow says[1] :—". . . south of the town [of Tamworth], in the coalfield area, there are a fair number [of springs]. As the various [Coal Measure] sandstones mostly dip into the hill they give out little water, but where the outcrop is cut open by a stream springs are fairly numerous. A specially large one rises from a sandstone of the Halesowen Group, where the outcrop has been cut into by a little stream about 1,200 yards N.E. of Wilnecote Church."

Bolehall and Glascote

BOLEHALL BORING. About 50 yds. east of the London Midland and Scottish Railway Viaduct, on the south side of Tamworth. Site shown on Geological Survey map, New Series, Sheet 154.

[1] ' Lichfield Memoir,' p. 221.

Made for the Tamworth Board in 1875. Particulars communicated by H. J. Clarson, Town Surveyor, and published in the 'Lichfield Memoir,' pp. 279, 280: see also p. 224. Top about 210 ft. above O.D.

		Thickness		Depth	
		Ft.	In.	Ft.	In.
	Made ground	3	0	3	0
[Keele Group]	Yellow sandstone-rock	4	0	7	0
	Red sandstone-rock	3	4	10	4
	,, marl...		4	10	8
	,, sandstone-rock	2	0	12	8
	,, marl-parting		2	12	10
	,, sandstone-rock	4	8	17	6
	,, marl-parting		2	17	8
	,, sandstone-rock	17	0	34	8
	,, marl-parting		2	34	10
	,, pebble-rock [pellet-sandstone]	4	2	39	0
	,, marl-parting		2	39	2
	,, pebble- rock [pellet - sandstone]	14	10	54	0
	,, marl-parting		2	54	2
	,, pebble-rock	8	8	62	10
	,, marl-parting		3	63	1
	,, sandstone	8	11	72	0
	,, marl-parting		2	72	2
	,, rock-marl		9	72	11
	,, rock		9	73	8
	,, strong mottled ground ...	5	10	79	6
	,, rock	4	6	84	0
	,, rock-marl	3	9	87	9
	,, pebble- [pellet] rock ...	6	5	94	2
	,, hard rock	4	0	98	2
	,, rock	2	10	101	0
	,, rock (very hard)	3	6	104	6
	,, rock	6	0	110	6
	,, rock (very hard)	9	6	120	0
	,, parting ... (water-bearing strata)		4	120	4
	,, rock ... (water-bearing strata)	8	4	128	8
	,, hard rock ... (water-bearing strata)		8	129	4
	,, marl and marl-rock ... (water-bearing strata)	8	6	137	10
	Light sandstone (water-bearing strata)	21	6	159	4
	Hard red rock	2	6	161	10
	Parting		2	162	0
	Hard red rock	1	4	163	4
	Rock-marl	2	0	165	4
	Light-red rock	1	8	167	0
	Bright-red marl	3	4	170	4
	Rock and rock-marl	8	6	178	10
	Red rock	1	0	179	10
	,, marl...	11	0	190	10
	,, rock	4	2	195	0

G. Barrow said in the 'Lichfield Memoir' (p. 224):—"The water, which still overflows at the surface in small quantity, contains nearly 48 grains of solids to the gallon, with a permanent hardness of 17·58. This shows the character of deep-seated water from the

Keele Beds, which are cemented by carbonate where they have not been decomposed." H. J. Martin erroneously said that the borehole was in the Waterstones (Keuper).

The following is an analysis made by E. W. T. Jones, Public Analyst for Wolverhampton, etc., and published in *Rep. Brit. Assoc.* for 1887, p. 366. In grains per gallon.

Total solid matter dried at 100°C.	...	47·95
Nitrogen as nitrates		[Not estimated]
Chlorine		2·170
Hardness : temporary (degrees)	... ...	8·75
permanent ,,	... ...	17·58
total ,,	... ...	26·33

WARWICKSHIRE MOOR. Water from Warwickshire Moor, 10 ft. below surface [in river-gravel of the Anker], in trial boring for Tamworth Rural Sanitary Authority. Analysis made by E. W. T. Jones, Public Analyst for Wolverhampton, etc., and published in *Rep. Brit. Assoc.* for 1887, p. 366. In grains per gallon.

Total solid matter dried at 100°C.	...	38·08
Nitrogen as nitrates...	...	1·522
Chlorine		1·960
Hardness : temporary (degrees)	... ...	12·61
permanent ,,	... ...	14·83
total ... ,,	... ...	27·44

Kingsbury

Dosthill is supplied by the Tamworth Waterworks Joint Committee ; Kingsbury village, Bodymoor Heath, Cliff, Coton, and Halloughton by the Rural District Council from their Dumbles Spring ; and Hurley, Hurley Common, Wood End, Edgehill, Whateley, and Foul End from the reservoir at Bentley which is filled from the Baxterley Well belonging to the Baddesley Collieries.

DUMBLES SPRING, at Dumbles, a quarter of a mile west of Waste Farm, 324·83 ft. O.D., from sandstone in the lower portion of the Keele Group—the Keele sandstones.[1] The average daily quantity of water obtained is 18,000 gallons, and a further 4,000 gallons per day could be obtained.

Quality of water.—Good. Hardness : total, 22·12° ; permanent, 6·86°. No action on lead ; contains some iron.

HURLEY SPRING. On June 24th, 1901, H. J. Clarson reported to the Tamworth Rural District Council on the ' Hurley Water Supply '.[2] " Near the village of Hurley and adjoining Hurley Hall, is situate a spring, known as the Nestles Spring [in Keele Group ground]. I have made gaugings of this spring, and I estimate that at the present time the daily supply of water is forty thousand

[1] *See* ' Lichfield Memoir,' p. 225.

[2] *Tamworth.* June 1901. Pp. 1-9.

gallons. This is the quantity of water that outcrops on the surface of the ground, and discharges into a brook course which passes close by the spring.

. . . . . .

" I am informed by old inhabitants of Hurley that the spring has never been known to be dry for the last fifty years . . ." He appended analyses of the Nestles Spring and Tamworth tap-water for comparison (see p. 79).

KINGSBURY COLLIERY SHAFT. A detailed section of this shaft is published in the ' Lichfield Memoir,' pp. 261, 262. Height above O.D. 310 ft.

	Thickness Ft.	In.	Depth Ft.	In.
Halesowen Group	239	6	239	6
Etruria Marl Group	239	4	478	10
Middle Coal Measures	431	6	910	4

" An account of this sinking (down to 682 ft.) and the methods of coping with the great volume of water encountered, is given in a paper by J. P. Kendrick ' On Sinking Operations at Kingsbury Colliery, Warwickshire,' *Trans. Fed. Inst. Mining Engineers*, vol. xiii, 1896-97, pp. 269-276. . . . The water occurred in the Halesowen Sandstone ; the first feeder, averaging 60,000 gallons an hour, was met with in the upper sandstones at a depth of about 135 ft. ; this is part of the thick brown sandstone . . . ; a second and similar feeder was met with at 192 ft. in the basal sandstone of this group. The underlying mass of Etruria Marl shut out any further serious inflow."

HURLEY SHAFT AND BORING. Site shown on Geological Survey map, New Series, Sheet 154, on which it occurs in the extreme south-east corner. Trial well and bore made for the Tamworth Rural District Council in 1892. Particulars communicated by H. J. Clarson, Surveyor, and published in the ' Lichfield Memoir,' p. 281 : see also pp. 217, 225. Top about 330 ft. above O.D.

		Thickness Ft.	In.	Depth Ft.	In.
[Keele Group.—sandstones]	Mainly red marl (the sunk well) ...	26	0	26	0
	Grey sandstone	8	5	34	5
	Red marl	7	0	41	5
	Marl and sandstone	3	7	45	0
	Red marl	23	10	68	10
	Grey rock	9	0	77	10
	Red sandstone rock	3	0	80	10
	Hard red rock	3	0	83	10
	Red marl and stone [sandstone] ...	23	0	106	10
	Blue marl	5	0	111	10
	Red marl and stone	30	2	142	0

G. Barrow said (' Lichfield Memoir,' p. 225) that the boring must have reached nearly to the base of the Keele Beds : also " The yield

was considerable, but the total was not tested, nor is there any published account of the quality of the water." Owing to possibility of contamination and loss of water by mining operations the use of the water for a public supply was not sanctioned.[1] The water is still overflowing into the brook.

Springs

G. Barrow says[2] :—" The most powerful springs . . . are those thrown out along faults. Along . . . that which bounds the western side of the Warwickshire Coalfields [in the area represented on New Series Sheet 154], almost impermeable Keuper Marl has been faulted against water-bearing rocks, thus forming a retaining wall behind which the water is impounded. The highest points of the wall are on the crests of the ridges between the valleys, and here no water can escape ; the lowest are in the valleys, and here the springs are the most powerful and numerous.

. . . . . .

" The course of the Western Boundary Fault of the Warwickshire Coalfield is marked at many points by powerful springs. Commencing at the southern end [of the area represented on Sheet 154] there is a strong spring at a small farm marked on the one-inch map a little west of the point where the Birmingham railway crosses a little stream to the south of Cliff. At this point there is marl at each side of the fault at the surface, but the water comes up from the Keuper Sandstone, and in such quantity that it keeps the marls in a state of sludge and the ground quick. Many cartloads of old bricks have been thrown into this to render it safe.

" Northward of this the Cambrian Rocks descend nearly to the alluvial flat, and almost all along the hill-foot and near the fault springs emerge, a few of which are noted on the six-inch map. About 180 yards south of Wigford Farm a large body of clear, bright water may be seen in dry weather issuing at the foot of the river-bank. It comes from the mouth of a drain-pipe laid to carry off the water rising from the Keuper Sandstone, beneath the Alluvium at the foot of the steep bank. The clearness of the water is in noticeable contrast with the foulness of that within the Alluvium itself. A large quantity of good water could be collected here.

" The condition of the Keuper Sandstone about Wigford shows that the rock becomes thoroughly porous and disintegrated when it is so situated that a free circulation of water is possible, and the whole of the interstitial calcareous material may be removed.

" Along the western branch of the Dosthill Fault a powerful spring of pure water rises on the west side of the Tame a few yards north of the canal-aqueduct. Before the installation of a public water-supply it was much resorted to by the inhabitants, and is still used by a few in summer-time.

[1] Local Government Board Inquiry, 14th Oct., 1903.
[2] ' Lichfield Memoir,' pp. 221, 222.

"A fault has been proved in the Kingsbury Colliery to pass close to the south-east corner of Kingsbury Wood, with a throw of about 120 ft. While along most of the escarpment the Keele Sandstones dip into the hill and the water follows this dip, near the fault they dip outward from the hill and give out springs. The strongest rise in a small extension of the main wood called the Dumbles on the six-inch map. The circulation of water has reduced the calcareous Keele Sandstone to a mass of loose sand. One of these springs is impounded in a small reservoir and supplies by gravity part of the Kingsbury area (Tamworth Rural District)."

Dosthill Mineral Springs. G. Barrow wrote[1]:—". . . under Dosthill House, two mineral springs rise close to the river-side; the more powerful is saline, and contains 460 grains of mineral matter to the gallon, nearly the whole being sodium chloride. The other is a chalybeate spring, and the existence of the two together caused the house close by to be for some years used as a sanatorium or spa. The old salt-bath is still in existence [between the footpath and River Tame west of Dosthill House], though much dilapidated, as is also a small reservoir into which ferruginous water oozes. The occurrence of these springs in line with others of pure water is difficult to explain. No bed of salt has been met with in wells or borings, and the only salt water known was found in the lower part of the Coal Measures in the Tamworth Colliery. Though the lower beds of these measures must be on the east side of the fault at Dosthill at no great depth down, no salt water has been elsewhere recorded from the mines. It is, however, a remarkable fact that the salt water at Tamworth Colliery was met with only when close to the continuation of this [Western Boundary] fault; it there came from the coal-face in large quantity. The amount of salts, almost entirely sodium chloride, is remarkable, being 2,030 grains to the gallon, or 2,900 parts to the 100,000.[2] It occurs in that part of the Warwickshire Coalfield which lies nearest to the western end of the Leicester Coalfield, where salt water is persistently present in the lowest coal seams. It would appear that the salt water is travelling in the coal-seams, but only in the immediate neighbourhood of the fault, and that therein lies the explanation of its absence in the other Warwickshire mines [but see p. 39]. Farther north springs of pure water issue from the fault."

Dosthill Quarry. Water from fissures in the igneous rock thrown out by the underlying Cambrian Shales in a hole in the lowest portion of the quarry. The water is pumped out of this hole. Analysis made by Messrs. Southall Bros. and Barclay, Ltd., Lower Priory, Birmingham. Sample received 12.9.1923.

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[1] 'Lichfield Memoir,' pp. 222, 223.

[2] Tested by J. S. Firth, Science Master at Tamworth Grammar School.

	Grains per gallon.
Total solid matter dried at 100°C.	54·6
Chlorine as chlorides	3·9
Saline ammonia	Absent
Albuminoid ammonia	0·0014
Nitrites	Absent
Nitrogen as nitrates...	0·2

Physical examination : Appearance clear, colourless, very slight pale brown deposit. No odour.

Hardness : temporary as $CaCO_3$	18·10
permanent ,, ,, ...	20·13
Oxygen absorbed : in 15 minutes	0·005
in 4 hours	0·060

	Grains per gallon.
Silica (SiO_2)	1·15
Iron and Alumina (Fe_2O_3 and Al_2O_3)	1·54
Lime (CaO)	15·48
Magnesia (MgO)	4·85
Sulphuric anhydride (SO_3)	16·42

The approximate composition of the dissolved solids is as follows :—

	Grains per gallon.
Silica (SiO_2)	1·15
Iron and Alumina (Fe_2O_3 and Al_2O_3)	1·54
Calcium carbonate ($CaCO_3$)	18·10
Calcium sulphate ($CaSO_4$)	12·91
Magnesium sulphate ($MgSO_4$)	13·48
Magnesium chloride ($MgCl_2$)	1·04
Sodium chloride (NaCl)	5·12
Sodium nitrate ($NaNO_3$)	1·21
Organic matter and combined water	0·05

Remarks :—In our opinion these figures indicate that the water is free from organic contamination and may be used with safety for drinking purposes. It is, however, very hard and for this reason we do not consider it a desirable water for general domestic use.

Middleton

Two undertakings, belonging to Lord Middleton, supply parts of this parish :—

Allen End Water Supply.—Near 9th milestone from Lichfield, in the valley of the Langley Brook is a windpump. It is said to be over a shallow well—near to where the Alluvium thins out on the rising bank of Keuper Marl—thought locally to be supplied with water from the brook (through the Alluvium). The water is raised to supply a farm and cottage. Reservoir : 3,000 gallons capacity.

Middleton Village Supply.—About a quarter of a mile west of the village is a windpump said to be over a shallow well presumably catching water that comes down the hill-side through a sprinkling

of gravel on Keuper Marl. The water is raised to a reservoir (capacity, 16,000 gallons) a little to the north of the church, from which about 17 houses and the schools are supplied.

The village is on boulder-clay—gravel and loam. Near the church is a public pump.

Seckington

The estate of Sir F. Burdett, Bart., on and to which the undertaking that supplies the whole of the village belonged, is now broken up. The following are particulars of the undertaking[1] :—

"Well . . . [in Lower Keuper Sandstone about a quarter of a mile south-west of] Seckington. The average daily quantity of water available is 2,500 gallons. No filtration. [Water raised from well by windpump to two] reservoir[s] at Seckington, 5,000 gallons. Quantity—Ample. Quality—Good."

Shuttington

Shuttington House, Tamworth.—On south side of Ashby Road, 3 miles north-east of Tamworth. About 260 ft. above Ordnance Datum.

Old well 53 ft., boring below to 112 ft.

"Sunk in the lower part of the Keele Group ; the boring was mainly in red marl and sandy marl (called ' binds ' by the borer). No water was met with till a bed of hard sandstone near the base [the Keele sandstones] was pierced ; the water then rose rapidly to within 50 ft. of the surface. The yield is ample, and there is no appreciable fall on pumping ; as it is for a private house it is not severely tested."[2]

Tamworth

St. Ruffin's Well.[3] This ' Well ' is a pool enclosed with brick walls, about 15 ft. by 12 ft., and once presumably had a high-pitched roof over it. A flight of six steps descends to the pool from a doorway in an adjacent building. The pool is maintained by a spring and the overflow finds its way into the River Anker. The water probably comes from gravelly drift on Keuper Marl.

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[1] ' Return as to Water Undertakings in England and Wales ' (1915), p. 331. *Local Gov. Bd.*

[2] G. Barrow, ' Lichfield Memoir,' p. 226.

[3] *See* ' The History of the Town and Castle of Tamworth ' (1845), p. 509.

Analyses, Tamworth Rural District

1. Dumbles Spring. 5.1.14. See p. 73. From Keele sandstone.
2. Baddesley Collieries, Ltd. 19.9.24. *Filtered and iron removed.*
3. Nestles Spring, near the village of Hurley and adjoining Hurley Hall. 40,000 gallons per 24 hours.
4. Tap water, Tamworth. From well in Hamstead (Enville) Group at Hopwas, which collects Bunter water. See 'Lichfield Memoir,' p. 224.
5. Hurley village. Well in sandstone of Keele Beds. 16.3.05.
6, 7. Hurley Common. Wells in ditto. 16.3.05.
8. Broomey Croft Farm, Kingsbury. Well in First River Terrace Gravel. 14.8.08.

Analyses by Messrs. Bostock Hill and Rigby, Birmingham.

Parts per 100,000.

	1	2	3	4	5	6	7	8
Free & saline ammonia	Trace	0·000	0·000	0·001	0·001	0·000	0·000	0·001
Organic ammonia	0·003	0·002	0·004	0·002	0·003	0·002	0·002	0·002
Chlorine in chlorides	2·600	2·500	2·100	3·300	5·800	6·100	1·800	3·400
Nitrogen in nitrates & nitrites	0·160	trace	trace	0·440	1·430	0·560	0·330	0·000
Oxygen absorbed in 4 hours at 80°F. ...	0·012	0·005	0·000	0·000	0·100	0·120	0·009	0·024
Total solid matter	52·000	53·000	42·000	38·000	80·000	68·000	46·000	304·000
Hardness: Temporary	21·8	7·8	22·50	18·25	—	—	—	—
Permanent	9·8	25·7	10·40	10·10	—	—	—	—
Total	31·6	35·5	32·90	28·35	—	—	—	—

Appearance :—

1. Bright, many small particles
2. Bright, few small particles. Iron absent.
3. 4. Clear, few small particles.

Remarks :—

5. Unsafe for drinking purposes.
6. Reasonably safe for drinking purposes.
7. Satisfactory.
8. Excessively hard—213 grains per gallon of hardening substances, chiefly Calcium Sulphate.

Warwick Rural District

The Warwick Rural District embraces the southern end of the Warwickshire Coalfield—the part southward of Coventry. Except for the extreme northern portion of the ' coalfield area ' which comes on the New Series maps, Sheets 168, 169, the geology of the District has not been revised : in consequence the rocks of the coalfield are represented as ' Enville (Corley) Group ' (? Upper Coal Measures) on the new Series maps and as ' Permian ' on the Old Series map, Sheet 53 N.W.

Lower Keuper Sandstone succeeds the Enville Group (or ' Permian ') unconformably and outcrops along a belt from a half to two miles wide extending from the vicinity of Coventry, *via* Baginton (west of), Bubbenhall, Blakedown Hill, and westwards to Leek Wootton. But the western boundary of the ' coalfield area ' is an approximately north and south fault extending from about half a mile west of Tilehill Station to Warwick, by which Keuper Marl is brought into juxtaposition with Enville Group beds.

Keuper Marl floors the remainder and greater part of the district. Glacial Deposits, Boulder Clay with associated sands and gravels, occur distributed sporadically over the surface of the ' solid ' rocks ; the ' coalfield area ' is the least obscured ; the Keuper Marl area the most. From north to south however, the Boulder Clay lessens in evidence and sands and gravels increase—pebbles being very widely distributed over the ground.

The sandstones in the Enville Group, where weathered, are productive of supplies to private wells, but, owing to their closely cemented nature, it remains to be proved whether they hold much water deep down and far from their outcrop.

The Lower Keuper Sandstone is the water-bearing bed of the district, but the water-level is kept down in its outcrop area by the River Avon. When entered by boreholes, that have penetrated a considerable thickness of overlying Keuper Marl, the water in the Sandstone is locally found to be rich in Sodium Chloride.

No complaints appear to have been received as to shortage of water in wells in the Keuper Marl, nor is there record of any of the waters in the wells being salty.

The sands and gravels (Superficial Deposits) on the surface of the Keuper Marl absorb water and are the sources of supply for many private wells and several small private piped services.

Baginton

Water from a spring situate 150 yards south of St. John the Baptist's Church that issues from sand and gravel associated with Boulder Clay which rests on Lower Keuper Sandstone (analysis, p. 87) is raised by a ram to a reservoir (about 5,000 gallons capacity) in the Hall grounds from which it gravitates and supplies 40 houses. At least three other springs issue from the same geological deposit

in the vicinity. Coventry Corporation water, however, is now laid on (4-inch main) in the village.

Beausale

A few wells go down to 70 feet.

Bishops Tachbrook

TACHBROOK MALLORY BORING. At the Court. Made in 1923 and particulars communicated by Messrs. C. Isler & Co., Ltd.

L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 301.

Height above O.D. about 226 feet.

		Thickness Ft.	Depth Ft.
	Soil	3	3
[Keuper Marl.]	Marly clay	8	11
	Red marl	12	23
	Grey marl	5	28
	Red marl with sand	10	38
	Red marl	22	60
	Red marl with sand	11	71
	Red marl	40½	111½
	Red and blue marl	8½	120
	Red marl	8	128
	Red and blue marl	7	135
	Red marl	6	141
	Red and blue marl	6	147
	Red marl	13½	160½
	Red marl and gypsum ...	7½	168
	Red marl	15	183
	Red marl and sand	7	190
	Red marl	4	194
	Hard rock	5½	199½
	Marl and small pebbles ...	5	204½
	Blue marl	4	208½
	Red marl and gypsum ...	39½	248
	Red marl and sand	8	256
	Red marl	12½	268½
	Red marl and sand	2	270½
	Sandstone	3	273½
	Red marl and sand	2½	276
	Blue marl	7	283
	Hard rock	4	287
	Sandstone	2	289
	Red marl	4⅓	293½
	Marl and sand	18½	312
	Red marl	11	323
	Marl and sand	4	327
[Lower Keuper Sandstone]	Sandstone	63	390
[? Enville Group]	Sandstone and marl	12	402
	Marl	43	445

Lined with 190 ft. of tubes 8½ in. in diameter, top 8½ ft. below surface.
165½ ft. ,, ,, 6½ in. ,, ,, ,, ,, 186 ft. ,, ,, ,,

Supply.—Mineral Water.

Analyses by Messrs. Bostock Hill & Rigby, Birmingham.

Received on : Sample No. 1, Oct. 25th, 1923.
No. 2, Nov. 2nd, ,,
No. 3, ,, 7th, ,,
No. 4, ,, 8th, ,,
No. 5, Dec. 5th, ,,
No. 6, ,, 8th, ,,

Parts per 100,000.

	1	2	3	4	5	6
Free and saline ammonia	0·028	0·065	0·064	—	0·072	0·072
Albuminoid ammonia ...	0·004	0·006	0·006	—	0·008	0·008
Chlorine in chlorides ...	4·7	14·9	17·3	19·8	23·65	22·2
Nitrogen in nitrates and nitrites	0·55	trace	trace	—	trace	trace
Oxygen absorbed from permanganate at 80°F. in 4 hours	—	0·052	0·035	—	0·025	0·031
Total solids dried at 100°C.	100	222	238	270	315	284
Hardness : Temporary	—	—	—	—	20	—
Permanent	—	—	—	—	115	—
Total ...	—	—	—	—	135	—

Sample No. 7 Report dated 11.12.1923.

Results of Mineral Analysis.		Probable Combinations.	
Carbon di-oxide ...	3·50	Calcium carbonate ...	7·96
Nitrogen pent-oxide ...	trace	,, sulphate ...	137·60
Sulphur tri-oxide ...	122·7	Magnesium sulphate	18·00
Calcium oxide	59·8	Sodium sulphate ...	55·60
Sodium oxide	45·0	,, chloride ...	38·96
Magnesium oxide ...	6·0		

Bubbenhall

A large spring issuing from sand and gravel (Superficial Deposits) in Bubbenhall Wood, is piped to a spout in the centre of the village and serves some 25 houses.

Cubbington

The village is dependent on shallow wells in an excellent sand-bed (Superficial Deposits) on Keuper Marl : water is met with practically anywhere at about 12 feet down.

Hatton

County Mental Hospital, Hatton. Boring made in 1912. Commented upon by L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 286.

Surface-level of engine-room floor.—330 ft. above O.D.

Boring :—14 in. diameter to 199 ft. 4½ in. (lined) ; 12 in. to 409 ft. 6 in. (lined with 10-inch tube) ; remainder 8 in.

		Thickness Ft.	In.	Depth Ft.	In.
Keuper Marl	Red marls, mottled	158	7	158	7
	Red marls with veins and layers of gypsum	116	5	275	0
	Gypsum		6	275	6
	Red marls, mottled, with veins and layers of gypsum	63	0	338	6
	Red marls, mottled, *devoid of gypsum*	31	9	370	3
	Dark grey sandstone ...	2	6	372	9
	Red and grey marly sandstone	7	0	379	9
	Red and grey rotten marl ...	4	0	383	9
	Red and grey marly sandstone	5	0	388	9
Lower Keuper Sandstone	Dark grey sandstone ...	1	0	389	9
	Reddish-grey marly sandstone		6	390	3
	Dark grey sandstone ...	5	9	396	0
	Grey sandstone	20	0	416	0
	Reddish-brown marl ...	2	0	418	0
	Grey sandstone with bands of reddish-brown sandy marl	14	0	432	0
	Grey sandstone	17	1	449	1
	Mottled sandy marl ...	4	7	453	8
	Grey sandstone	4	9	458	5
	Grey sandy marl	4	0	462	5
	Grey sandstone	37	7	500	0

Rest-level, 57 ft. 8 in. ex surface (June 15th, 1912), and 97 ft. 6 in. ex surface when pumping over 8,000 gallons per hour (May 24th, 1912). Yield 8,000 gallons per hour.

Honily

Within the moat north of St. John the Baptist's Church are two Holy Wells—St. John's Well and Our Lady's Well[1].

According to F. W. Shotton, two chalybeate springs, 150 yards apart, issue from the bank of Finham Brook near The Chase, 1 mile 4½ fur. north-east of Honily Church. The one spring is 300 yards north-east of The Chase, the other 300 yards east. " The brook has cut down, exposing good sections of bedded marls and coarse gravel from which the springs issue. Thick deposits of iron hydroxide are seen as in the stronger spring from Superficial Deposits at Balsall Common." (F.W.S. 8.8.1927).

Hunnington

Well at the (new) Vicarage.

Gravel	16 ft.
Keuper Marl	

Rest-level 7 ft. below the surface.

Leek Wootton

45 houses are supplied (by means of standpipes) by an undertaking belonging to Sir Wathen Walker with water obtained from the Warwick Town Council.

[1] A nunnery was founded here in King Stephen's time.

Well 600 yards [? S.W.] from the Church. Made in 1888 and particulars communicated by F. Holt, plumber, Warwick.

Record published by L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 298.

		Thickness Ft.	Depth Ft.
	Soil	4	4
Lower Keuper Sandstone]	Sandstone, white and red ...	48½	52½
[? Enville Group]	Marl	3½	56
	Sandstone	10	66
	Marl	19	85

Lillington

Well at new house in the southern angle made by the cross-roads about half-a-mile north-east by north from Blakedown House. Sinkers, G. Lines & Sons, Solihull; information from F. W. Shotton. Sunk February, 1927.

		Thickness Ft.	Depth Ft.
L. K. Sandstone	White sandstone	80	80
Enville Group	Marl	2	82
	Red sandstone	28	110

A roadside section immediately in front of the house shows Lower Keuper Sandstone dipping at an angle of 3°-4° in an east-south-easterly direction.

Marton

About 300 yards north 40° west of Marton Church, on the right bank of the River Leam is a small spring—issuing from sand and gravel (Superficial Deposits) on Keuper Marl—that in the past was held to be 'good for sore eyes.' The water has made a deposit of grey calcareous mud (which has been mistaken locally for salt) and is slightly chalybeate.

Offchurch

Most of the houses in the village are supplied from a good spring, the water of which is collected and pumped into a reservoir at Burnt Heath Farm.

A useful spring—draining Keuper Marl ground—comes down a 'limestone drain', about 4 ft. down (a trench in which are placed pieces of limestone and then filled up with marl), and discharges into the brook near where the Fosse Way crosses the canal. (Analysis, p. 87).

Radford Semele

The wells in the village are up to 90 feet in depth. A public pump is over a well that collects spring water.

A well and boring at Radford Brewery is said to have struck salt water which had to be plugged out.

Southam Road Well.

Well sunk May, 1927, in a field by a house in course of erection adjacent to the south side of the Southam Road at seven-twelfths-of-a-mile south-east by east of Radford Semele Church. L. Richardson, *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 3 for 1926 (1927), p. 303. Height above O.D. about 280 ft.

	Thickness Ft.	Depth Ft.
Upper (Chalky) Boulder Clay :—		
3. Brown and blue-blotched, tough, boulder clay, with flints, pebbles of chalk, subangular fragments of sparsely oolitic limestone (Jurassic), and small Bunter pebbles ...	9	9
2. Reddish coarse sand with comparatively few small Bunter pebbles, but numerous fragments of coal—especially in the upper 10 ft.	32	41
? Lower Boulder Clay :—		
1*a*. Pebbly red boulder clay : entered for ...	1	42

Rest-level 39 ft. 6 ins. down.

Rowington

The village is mostly on Keuper Marl and the wells are from 20–35 feet deep.

Sherborne

About 20 houses in the village are supplied from a spring near Morville, the water of which is pumped to a reservoir on Coplow Hill from which it gravitates.

Stoneleigh

Tile Hill Railway Station. Trial boring (10 in. diameter) for water, London and North Western Railway Goods Yard, Tile Hill Station. South side of railway at the eastern end of the yard.

Referred to by W. Andrews, *Proc. Warwickshire Nat. and Arch. F. C.* for 1897, p. 31 : ' Coventry Memoir ', p. 87 (reference to) ; p. 129 (summary of particulars).

Height above O.D., 352 ft.

This boring, apparently all in the Enville Group (Corley or Tile Hill Beds), passed through 693 ft. 3 in. of red and grey marls and sandstones.

Analyses.

No. 1 from pump. Mixture of Nos. 2 and 3. No. 2 from depth of 175 ft. No. 3 from depth of 300 ft.

	Hardness in degrees (Clark).		
	No. 1	No. 2	No. 3.
Temporary	20·0	21·2	17·3
Permanent	10·7	11·0	12·1
Total	30·7	32·2	29·4

Water too hard for boiler-feed.

KING'S HILL FARM. Near Hill (1-inch map, 3rd ed., Sheet 169). 1¼ miles north 2½° west of Stoneleigh Church. Well sunk December, 1926, by G. Lines & Sons, Solihull; information from F. W. Shotton.

	Thickness	Depth
	Ft.	Ft.
Red marl	80	80
Red sandstone	27	107

"Water found at about 60 ft. down, but lately [September 1927] has diminished to about one-sixth of the previous quantity." (G. Lines & Sons.).

Whitnash

A farm and the Golf-house are supplied from a shallow well fitted with a windpump.

"There was formerly an ancient well by the side of Whitnash brook, to the south of the footway from Whitnash to Radford, and concerning which this curious legend is told:—That the ancient inhabitants, when removing their bell from the ancient church to its present site, brought it to this holy well to be freshly consecrated. In doing this it fell into the water and gradually disappeared. The country people, who wish to know coming events, cast stones into the well at night, and in the morning their questions are answered by the sounding of the bell. The site is now drained, but the little stream of water which flows into the Whitnash brook is still believed to be possessed of healing power, and people come from great distances to procure the water".[1]

[1] Burgess, J. T., 'Historic Warwickshire' (2nd ed. 1893; 1st ed. 1875), pp. 232, 233.

Analyses, Warwick Rural District

1. Baginton. Well (new) in Lower Keuper Sandstone. 7.1.24.
2. ,, Well (new) in ditto. 12.9.21.
3. ,, Spring from sand and gravel (Drift) the water from which is forced up by a ram to a reservoir in Hall grounds (see p. 80). 27.9.21.
4. Barford. Well (new) in gravel. 19.8.24.
5. ,, Well (new) in gravel on Keuper Marl. 10.7.24.
6, 7. Cubbington. Wells (new) ' in running sand '. Cubbington Housing Scheme. (6) 18.4.21. (7) 18.4.21.
8. ,, Pringle Brook. Receives sewage. 6.10.20.
9. Leek Wootton. Spring from Lower Keuper Sandstone running into dip cut out of rock (Potter's Cottage). 10.5.23.
10. Offchurch. Spring from Superficial Deposits, Fosse Cottages. 19.7.20.
11. Radford. Well at Police Station, 93 ft. deep in Keuper Marl. 13.2.24.
12. Stoneleigh. Well (new) close to Tilehill Station in Tile Hill Beds. 7.1.24.
13. ,, Well (new) Gibbet Hill, in ' red clay ' (Enville Group). 19.8.24.

Analyses by Messrs. Bostock Hill & Rigby ; except 3, by Messrs. Southall Bros. & Barclay.

	Parts per 100,000		Grs. per gal.	Parts per 100,000.									
	1	2	3	4	5	6	7	8	9	10	11	12	13
Free and saline ammonia...	trace	0·0025	absent	0·006	0·0015	0·006	0·001	1·600	0·002	trace	0·001	0·0005	0·002
Albuminoid ammonia ...	0·004	0·004	0·0028	0·010	0·012	0·016	0·012	0·260	0·010	0·002	0·014	0·004	0·006
Chlorine in chlorides ...	1·300	2·300	6·3	2·850	14·600	2·100	2·300	5·900	2·100	2·500	3·300	3·000	1·650
Nitrogen in nitrates and nitrites	0·550	0·330	0·7	0·715	1·430	trace	0·880	1·050	0·220	0·330	0·550	0·440	0·770
Oxygen absorbed from permanganate at 80°F. in 4 hours	0·40	0·013		0·082	0·048	0·157	0·099	27·350	0·030	0·019	0·385	0·042	0·011
Total solids dried at 100°C.	30·000	36·000	75·8	67·000	134·000	34·000	62·000	138·000	42·000	76·000	72·000	50·000	31·000

Appearance :—

1, 2, 5, 9.	Bright, many small particles.
3.	Clear, colourless, slight odour.
4, 6, 10.	Opalescent, many small particles.
7.	Bright, few small particles.
8.	Brown and turbid, many small particles.
11, 12.	Turbid, many small particles.
13.	Bright, many large particles.

Remarks :—

1, 10, 12.	Satisfactory.
3, 9.	Fair.
4.	Unsafe for drinking purposes.
5.	Unsatisfactory for ditto.
11, 13.	Reasonably safe.

III.—WATER SUPPLIES OF URBAN DISTRICTS

Bulkington Urban District

The greater part of this Urban District is on Boulder Clay with associated sands and gravels in the lower portion. These Glacial Beds rest mostly on Keuper Marl; but westward of Weston Hall on Lower Keuper Sandstone. The Lower Keuper Sandstone occurs at the surface, uncovered by Boulder Clay, in the vicinity of Marston Gabbett, to the westward of which it thins out against Stockingford Shales (Cambrian) with intrusive diorites.

Bulkington village is on Glacial sands and gravel; Marston Gabbett on Lower Keuper Sandstone. The main part of the District on the Boulder Clay is very sparsely populated. The nature and thicknesses of the formations beneath Bulkington will be seen from the record of the boring given on p. 89.

Until the completion of the Bulkington Boring scheme all the houses derived their supply from shallow wells, the water in which was generally considered unfit for drinking purposes. The supply, however, was abundant, being in running (Glacial) sand from 8 to 20 feet below the surface. A good brook, springing from the sands in a wood known as the ' Fox Cover ', is the Wem Brook.

Weston-in-Arden Boring. Of a boring made in 1897, W. Andrews said[1] :—" Boring at Weston-in-Arden for water. This has been recently bored to a depth of 300 feet, through clays, marls and sandstones, with one bed of limestone[2] about half-way down. I have not had an opportunity of seeing the cores, but there can be little doubt that the whole, or nearly the whole, of the section is in coal measures. It is pointed out in the Government Survey Memoir on the Warwickshire Coal Field (p. 40) that the strata below the coal measures roll over and dip east; within a mile of this boring."

Prof. Charles Lapworth, in a Report, noticed presumably the same boring, which he said was made at Weston Hall in 1897 :—

Height above O.D. 369 ft. Borehole (diameter 7 in.) :—

		Thickness Ft.	Depth Ft.
Keuper Marl	... ...	154	154
Lower Keuper Sandstone	Sandstone, locally broken and false-bedded (base apparently not reached)	146	300

Rest-level, 70 ft. below the surface. Yield.—Tested to 500 gallons per hour.

It is not known for what reason Prof. Lapworth regarded all the beds below the Marl as Lower Keuper Sandstone. The 1924-25 Bulkington Boring proves that Andrews correctly surmised the nature of the strata penetrated.

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[1] *Proc. Warwickshire Nat. and Arch. F.C.* for 1897, p. 34.

[2] ? Index *Spirorbis*-Limestone.

BULKINGTON BORING. A little more than 100 yards south-west of the church, Bulkington. Made in 1924-25 for the Bulkington Urban District Council by Messrs. C. Isler & Co., Ltd. Recorded by Prof. W. S. Boulton, *Trans. Inst. Mining Eng.*, vol. lxx, pt. 2, 1925, pp. 69-78.

		Thickness Ft.	Depth Ft.
Drift	Soil	2	
	Dark-red sand	8	10
	Light yellowish-red running sand	10	20
	Dark-brown clay	32	52
Keuper Marl	Brownish-red marl	21	73
Lower Keuper Sandstone	Light-grey sandstone	11	84
	Red and blue mottled marl	3	87
	Fine-grained greenish-grey sandstone	11	98
? Halesowen Group	Purplish-red, pink, and lilac-blue non-calcareous clay, with purplish-red and blue-grey grit	37	135
	Hard very fine-grained grey sandy clay	8	143
	Hard red sandy marl	19	162
	Very hard bluish-grey sandy marl	47	209
	Light-grey sandstone, with scattered green and pale-pink grains, containing carbonaceous matter; dip 20°	16	225
	Tough blue-grey fireclay, with carbonaceous fragments	1	226
	Dark carbonaceous sandstone and sandy shale, full of poorly preserved plant-remains, and containing irregular nodules (3-4 inches) of clay ironstone	6	232
	Pale bluish-grey fireclay, with carbonaceous matter	2	234
	Dark bluish-grey tough clay, with woody matter	12	246
	Purplish-red and pale-blue mottled plastic clay	6	252
	Grey clay, with small lump of pale-bluish-grey oolitic ironstone. The nodule contains a smaller fragment, half-inch across, of dark-grey finer grained oolite, with scattered crystals of iron pyrites	3	255
	(Base of boring)		

According to log supplied by Messrs. C. Isler & Co., Ltd., the following beds were penetrated below 246 feet :—

		Thickness Ft.	Depth Ft.
? Halesowen Group	Red and blue mottled marl ...	8	254
	Dark red marl and ironstone balls...	2	256
	Fireclay	3	259
	Blue shale	4½	264½
	Grey shale	4½	269

The boring was done by percussion down to a depth of 209 feet, after which, and down to the bottom, cores, 6 inches in diameter, were drawn.

The classification for the Keuper is suggested by the writer: Prof. Boulton said :—" The Keuper. . . . is here only 46 feet thick, and consists of typical red and blue marl and grey sandstone. The Lower Keuper Sandstone is practically absent, unless the greenish-grey sandstone, 11 feet thick, which occurs at the base, is regarded as representing this formation." As regards the Coal-Measure series he said :—" It is certain that they lie below the Keele Beds " and that their characters " point to Halesowen Beds. "

Kenilworth Urban District

In general the western half of this Urban District is on Keuper Marl; the eastern on Enville Beds. The division-line is the Western Boundary Fault of the Coalfield—with an approximately north and south alignment—by which the Keuper Marl on the west is let down against the Enville Beds on the east. Lower Keuper Sandstone, however, emerges from beneath the Marl in a small tract in the neighbourhood of Stonymoor Wood adjacent to the fault-line, so probably it is not very deep down below the Marl of the other portion of the Keuper Marl tract.

The Enville Beds consist of marls with subordinate beds of sandstone. The most prominent sandstones consist of two beds separated by marl. The upper bed (with at least one thin layer of breccia) is exposed in Love Lane Quarry; the lower bed—for its greater part—has been pierced by the borings at the Waterworks. These Kenilworth Sandstones and Breccias would yield water—sufficient for small private supplies—to wells sunk in them. The Waterworks boreholes are said to obtain the bulk of their supply from sandstones at about 160½ feet below (No. 2 Borehole).

There are no springs of any note running to waste in the District, nor are there any borings other than those at the Waterworks.

Urban District Council Waterworks. Established as the Kenilworth Waterworks Co., Ltd., in 1883; purchased by the Council 30th June, 1922.

Sources of Supply.—At the Waterworks, The Common :—

Borehole No. 1 (1894) in pumping house bearing date 1895; Borehole No. 2 (1901) in separate pumping house; Borehole No. 3 (1914) in separate pumping house.

Until 1914 the original source of supply was in use, namely, an 'adit' in sandstone resting on marl (Enville Group) which, in turn, rests on sandstone (see p. 12). The adit is now filled in.

The average daily quantity of water derived from each source is —according to Sholto Douglas, Surveyor and Waterworks Engineer —respectively :—

(1) 57,100 gallons.
(2) 50,000 ,,
(3) 50,000 ,,
} Quality good. Analysis, p. 93.

No. 1 Boring.

Made in 1894 and particulars communicated by E. J. Tilley, London. Section published by W. Andrews, *Proc. Warwickshire Nat. and Arch. F. C.* for 1895, p. 56.

Height above O.D., 237 ft.

Shaft (about 6 ft.) and boring ('jumped') :—		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
	Subsoil	4	0	4	0
[Enville Group]	Red sand rock	15	6	19	6
	Rag	1	1	20	7
	Soft red sandstone	2	11	23	6
	Red and grey marl and sandstone boulders	35	6	59	0
	Red sandstone	2	6	61	6
	Red marl and thin veins of red rock	24	6	86	0
	Red marl	19	0	105	0
	Sand-rock	1	0	106	0
	Soft sandstone (water)		6	106	6
	Hard red sand-rock	6	6	113	0
	Red and grey marl	5	0	118	0
	Clayey marl	11	0	129	0
	Red sandstone	1	0	130	0
	Red and grey marl	4	0	134	0
	Red marl	41	0	175	0
	Hard red sandstone	2	7	177	7
	Red marl	5	5	183	0
	Red and grey marl	1	0	184	0
	Soft red sandstone	2	0	186	0
	Red and grey marl	7	0	193	0
	Red sand-rock	4	0	197	0
	Fine sand		7	197	7
	Hard red sandstone		3	197	10
	Fine sand	1	0	198	10
	Hard light-red rock	2	10	201	8
	Very hard red sand-rock	3	4	205	0
	Red marl	15	0	220	0
	Hard rock	3	0	223	0
	Red marl	3	6	226	6

Water-level.—Standing, 11 ft. 4 in. ex surface; pumping, 27 ft. 6 in. ex surface. Yield, 6,360 gallons per hour or 150,000 gallons per day (W. Andrews).

Andrews said :—" The whole of the water (except a very minute quantity at 106 ft.), is obtained between 193 and 205 feet from the group of sandstones, which it will be seen, are 12 feet thick."

Quality of Water.—Andrews said that the water was similar to that obtained at Spon End (Coventry Corporation Waterworks).

No. 2 Boring.

Made in 1901 and particulars communicated by Messrs. C. Isler & Co., Ltd. The particulars given in square brackets were obtained from an examination of small samples of the beds preserved at the Waterworks. Recorded by L. Richardson & W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 289.

Height above O.D., 237 feet.

			Thickness		Depth	
			Ft.	In.	Ft.	In.
[Enville Group.]		1. Top soil composed of ballast and marl [Drift]	8	4	8	4
	[Kenilworth Sandstones and Breccias]	2. Red and grey sandstone ...	3	0	11	4
		3. Very hard rock [calcareous sandstone]	9	2	20	6
		4. Red [friable] sandstone ...	3	6	24	0
	[Lower Enville Group Beds]	5. Red and grey marl	13	6	37	6
		6. Red-grey sandstone [sandy breccia]	2	6	40	0
		7. Red marl [red, green-spotted marl]	23	0	63	0
		8. Red and grey sandstone ...		6	63	6
		9. Red marl	26	6	90	0
		10. Sandstone	2	0	92	0
		11. Red-grey marl [red, green-veined marl]	3	0	95	0
		12. Sand-rock [sandstone] ...	12	0	170	0
		13. Red and grey marl	25	0	132	0
		14. Red sand-rock...	5	0	137	0
		15. Red-grey marl...	37	0	174	0
		16. Red-grey sandstone	4	6	178	6
		17. Red and grey marl	3	0	181	6
		18. Red-grey sand-rock	3	0	184	6
		19. Red sand-rock...	28	0	212	6
		20. Red and blue marl	19	6	230	0

Little water was encountered until bed 19 was entered.

No. 3 Boring.

Made in 1914 and particulars communicated by Messrs. C. Isler & Co., Ltd. Height above O.D., 237 ft.

		Thickness Ft.	Depth Ft.
[Enville Group]	Made ground	2	2
	Sand and stones	2	4
	Marl...	5½	9½
	Sandstone	12	21½
	Very hard rag	1½	23
	Marl and sandstone	12	35
	Red and grey sandstone ...	3	38
	Red marl	7	45
	Sandstone	9½	54½
	Sandstone and marl	33	87½
	Hard sandstone	27½	115
	Grey sandstone	3	118
	Red and grey marl	5	123
	,, sandstone	1	124
	,, and grey marl	4	128
	,, marl	40	168
	Sandstone	3	171
	Marl...	3	174
	Marl and sandstone	15	189
	Sandstone	9	198
	Hard sandstone	20	218
	Red marl	30	248
	Hard sandstone	12	260
	Red marl	7½	267½

Tubes:—130 ft. by 13½ in. top 6ft. down (bottom 30ft. perforated).
80 ft. by 11½ in. top 123 ft. down (perforated).
75 ft. by 10 in. top 191 ft. down (perforated).

Space outside 13½ inch tube filled with cement down to a ring fixed on tubes 50 ft. below surface.

Rest-level, 16 ft. ex surface.

I am informed (26 June, 1925) that the rest-level in all the boreholes is at about 20 ft. below the surface: also that in No. 3 Borehole little water was encountered until the sandstone between 198 and 218 ft. down was entered[1]. The bed of the Finham Brook adjacent to the Waterworks is in the sandstone penetrated between 9½ and 21½ feet down by the No. 3 Borehole.

Analysis.

Water mainly from sandstone between 198 and 218 ft. down (in No. 3 Borehole).

Made at the Public Health Laboratory, York Place, Manchester, 31st October, 1923, and communicated by Sholto Douglas, Surveyor and Waterworks Engineer.

[1] Compare remark by W. Andrews in respect of No. 1 Borehole.

Results expressed in parts per 100,000

Colour—Greenish. Turbidity—Slight. Smell—Indistinct.

Oxygen absorbed at 27° in 4 hours in acid solution ...		0·014
Free and saline ammonia	as NH_3	0·0006
Albuminoid ammonia	,,	0·0018
Nitrous nitrogen	,,	None
Nitric nitrogen	,,	0·092
Chlorides	as Cl	2·2
Phosphates	as H_3PO_4	present
Hardness—Temporary	as Ca CO_3	20·0
(Clarke's Method). Permanent...	,,	13·0
Total	,,	33·0

Reaction : Lacmoid—Alk. Methyl Orange—Alk.
Phenolphthalein—Acid.

Rugby Urban District

The Rugby Urban District is situate on Lower Lias, over the greater part of the surface of which are deposits of sand and gravel. The characters and thickness of the rocks beneath Rugby to a depth of 1145 ft. are shown by the ' Rugby Boring ' (p. 95).

Rugby Urban District Waterworks. Works established 1863.

Source of Supply.—River Avon at Brownsover Mill, north of the L.M. & S. Rly. Station, Rugby.

The average daily quantity of water derived is 715,169 and a further 884,831 gallons per day could be obtained.

Until May, 1924, there was a second source of supply, namely : —An upland gathering ground of 100 acres at the Barby Road Waterworks (Rugby & Hillmorton) of, locally, gravel and sand resting on Lower Lias, the water from which was collected by surface drains and shallow wells, and pumped into the Barby Road Water Tower (50,000 gallons). The average daily quantity of water derived from this source was 52,000 gallons, but owing to the construction of the Great Central Railway draining away water from the collecting ground and the area being developed for building purposes and the supply being locally polluted, this source of supply has been abandoned.

In 1923 the Council obtained an Act empowering them to construct additional waterworks. In general the scheme is as follows :— To construct an impounding reservoir, 134 acres in extent, to contain approximately 200 days' supply for Rugby, on the River Avon, just south of South Kilworth, with a collecting area of about 8 square miles ; and to convey the water from the reservoir through 15-inch iron socket pipes, approximately 7 miles long, closely following the course of the River Avon, to the Council's present reservoir at Brownsover.

Analysis

Public Supply from River Avon (draining a tract of Lower Lias with Drift resting locally on its surface), May 12, 1868.

Sixth Report (1874), Rivers Pollution Commission, p. 50.

	Parts per 100,000
Total solid impurity	26·24
Organic carbon	·123
Organic nitrogen	·037
Ammonia	·002
Nitrogen as nitrates and nitrites... ...	·382
Total combined nitrogen	·421
Previous sewage or animal contamination	3,512
Chlorine	2·03
Hardness: Temporary	6·8
Permanent	9·1
Total	15·9

RUGBY BORING. Near the Water Tower on the Barby Road, at a distance of approximately 1½ miles to the south of the British Thomson-Houston Boring (see p. 96).

Made in 1862 for the Rugby Board of Health.

1869. Smith, T. McD.—Account of the Rugby Well, etc.

1869. Wilson, J. M.—Rugby Waterworks. Remarks to accompany the Section of the Well. *Rep. Rugby School Nat. Hist. Soc.* for 1868, pp. 41, 42.

1875. Hawksley, T.—Report upon the Boring for Water at Rugby, 1862: with Notes on the Composition [of the water] by Dr. W. Odling. *Idem* for 1874, pp. 71-73. *Rep. Brit. Assoc.* for 1887, p. 364.

1879. Twamley, C.—[Summary of record] *Proc. Warwickshire Nat. and Arch. F. C.* for 1878, p. 19.

1893. Woodward, H. B.—Jurassic Rocks, etc., vol. iii, p. 165 [Lias portion of record]. *Mem. Geol. Surv.*

1912. Richardson, L.—'The Rhaetic Rocks of Warwickshire,' *Geol. Mag.*, p. 33.

Slight differences occur in certain of the above publications with reference to the particulars of the strata penetrated, but they are unimportant.

Height above O.D., 360 ft.

	Shaft (82 ft. × 7 ft.) and boring:—	Thickness Ft.	In.	Depth Ft.	In.
[Drift.]	1. Red sand and gravel ...	10	0	10	0
[Lower Lias]	2. Blue clay with a band of limestone	119	0	129	0
	3. Limestone	4	0	133	0
	4. Clay	6	0	139	0
	5. Alternate bands of clay and limestone	11	0	150	0
	6. Clay with four bands of limestone	53	0	203	0
	7. Alternate bands of clay and limestone	147	9	350	9
	8. Clay	6	0	356	9
	9. Limestone	4	0	360	9
	10. Clay	27	3	388	0
	11. Limestone [Cement Stone].	12	0	400	0
	12. Clay	2	0	402	0
	13. Dark rotten clay	38	0	440	0

		Thickness Ft.	In.	Depth Ft.	In.
[? Rhaetic]	14. Brown clay [? Upper Rhaetic]	20	0	460	0
	15. Black clay [? Rhaetic black shales]	8	0	468	0
	108 ft. below O.D.				
[Keuper Marl]	16. Light hard stone [? Tea-green Marls]	10	0	478	0
	17. Red clay	24	0	502	0
	18. Blue clay	2	6	504	6
	19. Red clay	8	6	513	0
	20. Blue clay	3	0	516	0
	21. Red clay	62	0	578	0
	22. Blue stone	3	0	581	0
	23. Red clay	35	6	616	6
	24. Blue stone		3	616	9
	25. Red clay	163	3	780	0
	26. Red sandstone [Arden Sandstone]	6	0	786	0
	27. Red clay	40	0	826	0
	28. Blue stone	1	0	827	0
	29. Red clay	219	0	1046	0
	30. Red clay (sandy)	99	0	1145	0
[L.K. Sandstone]	31. Waterstone				

Lined with cast iron pipe from 82 to 143 ft.; and wrought iron tubes

12	in. in diameter	,,	234½ ft.
10	in. ,,	,,	470½ ft.
9	in. ,,	,,	751 ft.
7½	in. ,,	,,	784 ft.
6½	in. ,,	,,	1030 ft.
6	in. ,,	,,	1128 ft.

J. M. Wilson regarded beds 13, 14 and ? 15 (as numbered above) as Rhaetic (table facing p. 40) and said (p. 42) that " Water-stones were reached, at a depth of 1145 feet."

Gypsum occurred practically throughout the red Keuper Marl. On coming near the Lower Keuper Sandstone at 1140 ft. water rose in the borehole but was found to be so impregnated with salt and gypsum as to be useless.

In 1912 I made some remarks as to which were Rhaetic beds in the record of the strata penetrated by this boring. I would now withdraw those remarks and merely observe that the description " Black clay " for the bed I have numbered 15 above seems to suggest Lower Rhaetic Black Shales.

THE BRITISH THOMSON-HOUSTON CO., LTD. Boring situate 20 ft. from south bank of the River Avon near the old power house of the British Thomson-Houston Co., Ltd.

Made in 1900-1901 and communicated by Messrs. C. Isler & Co., Ltd. The numbers against the beds have been added.

Height above O.D., 280·64 ft.

		Thickness Ft.	In.	Depth Ft.	In.
	Dug well	8	0	8	0
	Boring :—				
[Lower Lias]	1. Clay	35	0	43	0
	2. Clay with layers of stone ...	40	0	83	0
	3. Cement-stone, 4 ft., and rock, 1 ft.	5	0	88	0
	4. Stone and layers of clay ...	140	0	228	0
	5. Blue clay	17	0	245	0
	6. Rock, 5½ ft., and rock [Cement Stone] 9 ft.	14	6	259	6
	7. Brown clay	17	0	276	6
	8. Rock	5	0	281	6
	9. Blue and brown clay	24	6	306	0
[? Rhaetic]	10. Rock	13	6	319	6
	11. Black clay	2	0	321	6
	40·86 ft. below O.D.				
[Keuper Marl]	12. Rock	12	6	334	0
	13. Clay and rock	2	0	336	0
	14. Red clay	9	0	345	0
	15. Red rock	1	0	346	0
	16. Rock and clay	12	0	358	0
	17. Rock		6	358	6
	18. Red clay	4	6	363	0
	19. Rock and green clay	3	0	366	0
	20. White rock and red clay ...	4	6	370	6
	21. Marl	3	6	374	0
	22. Red clay	6	0	380	0
	23. ,, ,, and gypsum ...	13	0	393	0
	24. ,, ,, ...	1	0	394	0
	25. ,, ,, and gypsum ...	2	0	396	0
	26. Gypsum	2	0	398	0
	27. Red clay	2	0	400	0

Lined with 20 ft. of tubes, 7¼ in. in diameter, top 5 ft. down.

141 ft. ,, 6 in. ,, ,, 1 ft. ,,

266½ ft. ,, 5 in. ,, ,, 133 ft. ,, (perforated)

Water-level, 1 ft. ex surface. The water is ejected by compressed air.

Yield, 360 gallons per 24 hours (approximately).

Quality of Water.—Analysis, pp. 98, 99. The water is used for drinking purposes in the summer time.

Bed 10 may be Rhaetic White Lias and ? Cotham Beds, and the description of the bed numbered 11—" Black clay "—is suggestive of Lower Rhaetic Black Shales.

TABLE I. General Chemical Analysis of Water from 400 ft. Well Situated 20 ft. from South Bank of the River Avon near North Wall of the old Power House of Messrs. The British Thomson-Houston Co., Ltd., Rugby.

Date of Sampling and Testing.	1902 May	1911 Sept.	1916 June 8th	1924 June 17th	1924 June 17th
Analyst.	W.B.P.[1] (B.T.H.)	H.R.[2] (B.T.H.)	Prof. P.F.F.[3]	W.T.B.[4]	G.T.[5] (B.T.H.)
Item.	Grains per Gallon.				
Total Solids (dried 100° to 110°C.)	118·68	117·56	110·95 Dried at 148°C.	108·5	105·5
Analysis of Solids.					
Silica .....SiO_2	2·52	0·47	0·49	0·45	0·58
Oxides of iron & aluminium...Fe_2O_3...Al_2O_3	0·64	traces	0·17	0·14	0·20
Calcium oxide .....CaO	2·76	1·30	1·58	1·15	1·39
Magnesium oxide .....MgO	trace	1·27	1·197	1·26	1·48
Sodium oxide .....Na_2O	not detrmd.	46·14	51·548	not detrmd.	46·98
Potassium oxide .....K_2O	not detrmd.	10·54	included in Na_2O	not detrmd.	1·60
Sulphuric anhydride .....SO_3	40·91	33·72	31·10	27·34	26·69
Carbonic anhydride.....CO_2 left fixed as normal carbonates upon evaporation	not detrmd.	13·51	14·12	13·65	13·81
Chlorine (combined) .....Cl_2	12·95	12·26	12·25	12·95	13·45
Nitric oxide .....N_2O_5	—	1·08	—	0·18	0·27
Nitrous oxide .....N_2O_3	—	—	—	—	—
Ammonia saline (Free)	not detrmd.	not detrmd.	0·038	0·001	0·004
Ammonia albuminoid	,, ,,	,, ,,	trace	0·002	—
Ammonia total	,, ,,	,, ,,	0·038	0·003	—
Total combined nitrogen	,, ,,	,, ,,	0·070	0·059	—
Nitrogen as nitrates	,, ,,	,, ,,	0·020	0·048	—
Nitrogen as nitrites	,, ,,	,, ,,		trace	—
Organic nitrogen	,, ,,	,, ,,	0·018	0·01	—
Organic carbon	,, ,,	,, ,,	0·086	0·11	—
Oxygen absorbed in 4 hrs. at 27·0°C....	,, ,,	,, ,,	0·022	0·036	—
Total hardness in terms of $CaCO_3$ ..... (Calculated from CaO & MgO)	4·93	4·96	6·53	5·18	6·19
Temporary hardness by titration	4·93	4·96	5·53	—	4·71
Permanent hardness by difference	nil	nil	0·98	—	1·48
Free carbonic acid gas .....CO_2	not detrmd.	not detrmd.	—	—	nil
Free oxygen gas .....O_2	not detrmd.	not detrmd.	—	—	7·4 ccs. per 1000 ccs.

[1] W. B. Parker, F.I.C., Chief Chemist, B.T.H. Co., Ltd. [2] H. Robinson, formerly Chief Assistant Chemist, B.T.H. Co., Ltd.
[3] Prof. P. F. Frankland, F.R.S., [4] Wm. T. Burgess, F.I.C., Consulting Chemist, Bedford Park, London, W.4.
[5] Miss G. Thompson, B.Sc., F.I.C., Research Chemist, B.T.H. Co., Ltd.

TABLE II. Mineral Analysis (Calculated) of Water from 400 ft. Well Situated 20 ft. from South Bank of River Avon near North Wall of the Old Power House of Messrs. The B. T. H. Co., Ltd., Rugby.

This Table Expresses the Probable Combination of the Ingredients Given in Table I.

Date of Sampling and Testing.	1902 May	1911 Sept.	1916 June 8th	1924 June 17th	1924 June 17th
Analyst	W.B.P. (B.T.H.)	H.R. (B.T.H.)	Prof. P.F.F.	W.T.B.	G.T. (B.T.H.)
Item.	Grains per Gallon.				
Total solids (dried 100° to 110°C.)	118·68	117·56	110·95 Dried at 148°C.	108·5	105·5
Composition of Solids.					
Silica SiO_2	2·52	0·47	—	—	—
Oxides of iron & aluminium Fe_2O_3 Al_2O_3	0·64	traces	0·17	0·14	0·20
Sodium silicate Na_2SiO_3	—	—	0·99	0·91	1·16
Calcium carbonate $CaCO_3$	4·93	2·33	2·81	2·03	2·48
Magnesium carbonate $MgCO_3$	trace	2·66	2·51	2·66	3·11
Sodium carbonate Na_2CO_3	31·61	26·74	27·71	27·37	26·71
Sodium chloride $NaCl$	21·61 – (NaCl)	7·11 16·69	20·18 – (NaCl)	21·35 – (NaCl)	20·18 2·53
Potassium chloride KCl					
Sodium sulphate Na_2SO_4	57·61	59·84	55·20	48·58	47·38
Sodium nitrate $NaNO_3$	not detrmd.	1·70	0·12	0·28	0·42
	118·92	117·54	109·69	103·32	104·17

IV.—WATER SUPPLIES OF MUNICIPAL BOROUGHS

Borough of Nuneaton

The geology of the Borough of Nuneaton is shown on the Geological Survey maps—one-inch, New Series, Sheet 169, and six-inch Sheets 10 N.E., S.E., 11 N.W., S.W., 16 N.E., 17 N.W. It is unnecessary therefore to go into details here; it will suffice to say that a fault having a north-west and south-east alignment traverses the town, to the north-east of which is Keuper Marl, while to the south-west come Cambrian beds followed by Coal Measures. South-west of the fault, southwards of the town, the Cambrian beds are partly hidden by Lower Keuper Sandstone; while, locally, deposits of Glacial age—sand, gravel and boulder-clay—occur on the surface of the 'solid' rocks.

Sandstone strata, namely, the 100-Feet and 4-Feet Sandstones, occur in the Halesowen Group and Middle Coal Measures respectively of the area; but—as mentioned at an earlier page (p. 12)—supplies from them are pretty well exhausted, and, as a result, to make sure provision for an adequate supply the Corporation has arranged with the Leicester Corporation to have water from the latter's Thornton Reservoir.

Nuneaton Corporation Waterworks

Nuneaton Town Council.—Works established as the East Warwickshire Waterworks Company by virtue of Act of 1882. Purchased by the Nuneaton T. C. by Act of 1897. Supplies Nuneaton Borough (8,550 out of 8,843 houses).

Sources of Supply.—Wells at: (1) Robinson's End (see below); (2) Whittleford (p. 104); (3) Clara (Well), Griff (p. 107)—use discontinued at the end of 1925. (4) Water supplied by agreement with the Leicester Corporation from the Thornton Reservoir, the main from which to Leicester is tapped near Desford Station, where it is pumped to the Nuneaton Corporation's reservoir at Tuttle Hill, Nuneaton.

The daily average quantity of water derived from each source is respectively:—(1) 80,000 gallons, (2) 636,000 gallons, (3) 115,000 gallons, (4) 250,000 gallons (minimum) until 31st December, 1925; 500,000 gallons (minimum) from 1st January, 1926 to 31st December, 1930; 750,000 gallons (minimum) from 1st January, 1931, to 31st December, 1935; and 1,000,000 gallons from 1st January, 1936, to the end of a period of 40 years from connection of mains.

Robinson's End Wells.[1] 1.—First or Old Well. Section, differing in a few details, published in *Rep. Brit. Assoc.* for 1890,

[1] Referred to in places in reports and literature as the Tower Farm, Tower, and (in *Rep. Brit. Assoc.* for 1890) Stockingford Well.

pp. 374, 375. See also 'Coventry Memoir,' p. 128 (summaries of particulars in respect of 'Old' and 'New' Wells). Surface-level,[1] 464 ft. above O.D.

Well (10 by 6 ft. in diameter to 336 ft.; borehole, ? in. in diameter to 396 ft.):

		Thickness		Depth	
		Ft.	In.	Ft.	In.
Lower part of Keele and top of Halesowen Groups (Upper Coal Measures)	Strong brown clay	67	0	67	0
	Light blue rock	3	8	70	8
	Marl with balls of red rock ...	97	10	168	6
	Strong marl	15	6	184	0
	Red rock	1	6	185	6
	Dark grey rock	2	0	187	6
	Red marl	4	0	191	6
	Marl with balls of red rock ...	3	0	194	6
	Red rock	2	0	196	6
	Marl with balls of red rock ...	2	9	199	3
	Red rock	1	9	201	0
	Red marl		6	201	6
	Red rock	2	10	204	4
	Marl with light rock	35	8	240	0
	Light rock	1	6	241	6
	Sandstone rock	8	9	250	3
	Peldon	4	0	254	3
	Sandstone	8	9	263	0
	Fine light rock, very strong ...	6	6	269	6
	Red rocky marl	6	0	275	6
	Light soft marl	2	6	278	0
	Marl with balls of red rock ...	29	6	307	6
	[40-Feet Sandstone] Sandstone...	24	6	332	0
	Light red rocky marl	6	0	338	0
	Hard sandstone	2	0	340	0
	Marl...	30	0	370	0
	Light rock	6	0	376	0
	White rock, very strong	9	0	385	0
	Strong marl	1	9	386	9
	Sandstone	2	0	388	9
	Strong rocky marl...	4	9	393	6
	Red marl	2	6	396	0

Water-level (rest), 230 ft. ex surface. Long disused as source of supply.

This well was originally sunk by the East Warwickshire Waterworks Company in 1882—completely from the surface—for the supply of Nuneaton. The spot was selected by Mr. Anstie, the Engineer for the Company, chiefly upon geologic considerations as lying near the centre of the main synclinal of the 'Permian' (now Upper Carboniferous) of the country. In the light of the geological knowledge then possessed of the water-bearing rocks of the district the selection was admirable.

[1] The figure given for the surface-level will be found to vary in literature: this is mainly due to the fact that the ground has subsided owing to mining operations. While damage has been done to reservoirs Nos. 1 and 2, here, curiously enough, no damage has been done to the original Pumping Station (*see* F. C. Cook and R. C. Moon, *Trans. Inst. Water Eng.*, vol. xxv (1921), pp. 176-190).

No water was encountered until the shaft had reached a depth of some 240 ft., at which level 40,000 gallons per day were obtained.

At 303 ft. a second water-bearing stratum was tapped and an additional 40,000 gallons per day were procured. This yield was next increased by a third 40,000 per gallons day by means of a level heading. This appears to have been in June, 1888, and the total supply from this well, at that date, was 120,000 gallons per day.

In 1889 the well was deepened to 336 ft. and headings were driven into the water-bearing rock. These two improvements increased the supply to 150,000 gallons per day.

2.—SECOND OR NEW WELL. About 12 yds. distant from the First Well.

Well (10 ft. in diameter to ? ft.; borehole, ? in. in diameter to 571½ ft.):

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Lower part of Keele, and Halesowen Sandstone Groups.]	[Strata as in First Well]			336	0
	Blue rock	24	0	360	0
	Rock	6	0	366	0
	Red marl	2	0	368	0
	Rocky marl	3	0	371	0
	Blue rock	12	0	383	0
	Fireclay		6	383	0
	Brown rock	3	0	386	6
	Rock binds	4	0	390	6
	Rock	4	2	394	8
	Rocky marl	4	5	399	1
	Marl...	2	3	401	4
	Pricking		4	401	8
	Rocky marl	6	4	408	0
	White rock	3	0	411	0
	[Index-] Limestone	1	9	412	9
	White rock	1	9	414	6
	Marl, red		9	415	3
	Rocky marl	11	0	426	3
	Red marl	12	0	438	3
	White marl...	7	0	445	3
	Red marl	6	6	451	9
	Strong white rock marl	2	6	454	3
	White marl...	10	0	464	3
	Rocky binds	18	0	482	3
	Brown and white marl	33	8	515	11
	Binds	20	9	536	8
	Dark clunch ground	1	0	537	8
	Light rock binds	7	4	545	0
	[100-Feet Sandstone] White sand-rock ...	10	6	555	6
	[100-Feet Sandstone] White rocky-marl ...	11	6	567	0
	[100-Feet Sandstone] White sand-rock ...	4	6	571	6

Subsequently deepened and borings made (see p. 103)

Now used as a standby.

The Second Well was commenced in 1890 and sunk to a depth of 330 ft. It increased the total yield by about 46,000 gallons, raising the quantity from the two wells to 196,000 gallons per day.

In 1892, as the demand for water was in excess of the supply, this Second Well was deepened by 159 ft. to 489 ft. ; but then the yield from the First Well began to fall off.

Although additional water had been obtained from the Second Well the total yield from the two wells early in 1893 became actually less than that afforded by the First Well at its best.

In 1893 the Second Well was deepened to 495 ft. ; but the total supply, nevertheless, dwindled down to 120,000 gallons per day.

In 1894 the Second Well was carried down to the 100-Feet Sandstone, to a depth of from 588 to 600 ft., but with little result, as the final yield of the two wells was only 130,000 gallons per day.

In January, 1895, boreholes were sunk to a further depth of 69 ft. in the bottom sandstone. Tunnels and headings were then driven into the sides of the well near the top of the 100-Feet Sandstone, at a depth of 575 ft., but with disappointing results, little additional water being obtained from them. In June, 1895, as it was considered that the rock in the Second Well had been sufficiently tested, all work in the headings was suspended.

Prof. Charles Lapworth, in a Report from which the above information has been mainly derived, said :—" We see therefore, from the foregoing facts, that the rock-layers at the Tower Wells have been fully tested to a depth of nearly 200 yards ; and that the total yield from them is less by 25,000 gallons than from the First Well alone in 1889. This shows that the water originally tapped in these wells, exactly as has been the case elsewhere, was in part a ' pound '—or an old accumulation of underground water ; and that the original supply of the wells was no safe criterion of the supply that might be expected permanently. Indeed, the supply from the First Well has decreased from 150,000 to 60,000 gallons.

" Disheartening as this may seem there is nothing novel in the fact of this natural decrease from the original quantity. The permanent supply of a well may be generally set down roughly at from a half to a third of the first year's supply.

" When we compare the section of the Tower Wells with all the sections of the various collieries ranging from Exhall on the south to the Tunnel Colliery on the north we see that the Tower Well was the first to pierce the 40-Feet Sandstone.

" The 40-Feet Sandstone has a very wide outcrop round the well, and this width accounts for the fairly good supply of water which it yields the Tower Wells.

" At Hickman's [Tunnel] pit little water was obtained from this 40-Feet Sandstone, as the outcrop there is not large, while the Tower Wells had already abstracted the bulk of its pounded waters, as the 40-Feet Sandstone dips down from Hickman's pit to the Tower Wells.

" The 100-Feet Sandstone, which is the great water-bearing sandstone of Exhall and Griff, occurs in the Second Well but is only just tapped ; and headings have been driven recently, in the *top* of this sandstone instead of in the *bottom* as they should have been in order to secure the greatest possible amount of water.

" The 100-Feet Sandstone, even at Hickman's shaft (Tunnel Pits), only yields 70,000 gallons of water per day, on account of its being so far removed from the outcrop ; and I doubt much if the 100-Feet Sandstone in the Tower Well will yield even this amount. Nevertheless the quality of the water yielded by the 100-Feet Sandstone is so good at this distance from the outcrop (more than one mile), that I would strongly urge that the Tower Well be sunk right down to the base of the 100-Feet Sandstone, to test its water-yield, once for all.

" No deepening or enlarging of these Tower Wells could possibly obtain a permanent yield of water sufficient for the town supply of Nuneaton. The 150,000 gallons per day already proved to be about the permanent yield is, I am afraid, as much as can be reasonably expected at this Tower locality."

The yield from the Robinson's End Wells was not maintained and when the failure became apparent the East Warwickshire Water Company—to whom they then belonged—decided about 1895 to promote a bill in Parliament with the object of obtaining a supply from Kingsbury. This project, however, was dropped prior to the purchase of the Waterworks by the then Nuneaton and Chilvers Coton Urban District Council in 1897.

Analysis.

From wells in the lower part of the Keele and top of the Halesowen Group (Upper Coal Measures). Analysis by Messrs. Bostock Hill and Rigby, Birmingham. 9.8.1899.

	Parts per 100,000
Total solid impurity	40
Free ammonia	·001
Organic ammonia	·004
Nitrogen as nitrates and nitrites	0
Total combined nitrogen	—
Oxygen absorbed in 4 hrs.	—
Chlorine	2·3
Hardness : total	23·92

Appearance.—Clear.

Whittleford Well. Begun as a colliery shaft. Surface-level, 365 ft. above O.D.

		Thickness Ft.	In.	Depth Ft.	In.
	Made ground	3	0	3	0
	Soil	1	0	4	0
	Yellow clay	2	0	6	0
	Red marl	9	0	15	0
	Red marl with layers of sandstone containing water	9	0	24	0
	Red marl	2	0	26	0
	Red sandstone	4	0	30	0
	Red marl and occasional sandstone	11	6	41	6
	Grey sandstone yielding 1,000 gallons per hour of very hard water	3	6	45	0
	Red marl	8	8	53	8
	Grey sandstone yielding 1,000 gallons per hour of very hard water	6	0	59	8
	Purple marl	5	0	64	8
	Conglomerate		4	65	0
	Red sandstone	4	3	69	3
	Red marl	7	0	76	3
	Dark grey sandstone	3	11	80	2
	Blue mottled marl	16	10	97	0
	Brown mottled marl	2	6	99	6
	Blue marl	7	6	107	0
	Brown marl	19	5	126	5
	Light marl with brown layers ...	2	6	128	11
[Lower part of Keele Beds, and Halesowen Group]	Dark mottled marl	9	10	138	9
	Strong light blue marl	8	10	147	7
	Light sandstone		9	148	4
	Light marl	2	3	150	7
	Brown marl	3	0	153	7
	Light marl	1	0	154	7
	Light rough rock	1	0	155	7
	Light sandstone yielding 400 gallons of water per hour	3	0	158	7
	Red marl	2	0	160	7
	Red and light marl in layers ...	2	0	162	7
	Light marl	2	9	165	4
	Red marl	4	7	169	11
	Strong light marl with layers of red	6	0	175	11
	Brown marl	2	0	177	11
	Strong white marl	1	9	179	8
	Light blue marl	10	7	190	3
	Grey sandstone layers		6	190	9
	Light blue marl with layers of red marl	6	0	196	9
	Brown marl	3	6	200	3
	Strong light blue marl yielding 400 gallons of water per hour ...	8	6	208	9
	Light mottled marl	15	3	224	0
	Light blue marl	8	0	232	0
	Blue rough sandstone yielding water	15	0	247	0
	Light binds	3	0	250	0
	Black ring		2	250	2
	Light sandy marl	6	2	256	4
	Light blue binds	9	0	265	4

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Lower part of Keele Beds, and Halesowen Group]	Brown and mottled marl ...	4	0	269	4
	Light rough sandstone	10	6	279	10
	Rock binds	10	5	290	3
	Blue coarse rough rock	2	8	292	11
	Blue binds	2	4	295	3
	Brown marl	22	8	317	11
	Light fireclay	1	6	319	5
	Brown marl	2	0	321	5
	Light sandstone yielding 1,000 gallons of water per hour ...	3	0	324	5
	Rough sandy marl yielding water	19	6	343	11
	Light grey sandstone [100-Feet Sandstone]	16	1	360	0

Yield, 67,200 gallons per 24 hours ('Coventry Memoir,' p. 130).

The Whittleford Well along with another shaft were sunk originally as colliery shafts, but so much water was encountered during sinking operations that the pumps were drowned out and the work had to be abandoned at a depth of 360 ft.

In 1897 the Nuneaton Corporation promoted a Bill in Parliament to acquire the abandoned sinkings and Pumping Station and brought the Station into use in 1901.

The daily average quantity of water pumped in

1903 was	443,761 gallons
1905	430,104 ,,
1907 (maximum)	452,957 ,,
1908	441,360 ,,

This average, however, was only maintained by gradually lowering the pumps from 180 to 276 ft., and, in 1905, by driving a heading from the first shaft into the second shaft which resulted in the augmentation of the supply by about 50,000 gallons per day.

In November, 1908, the quantity of water pumped diminished, and from November, 1908, to March, 1909, the supply fell to an average of 395,457 gallons per day. The wells were fed with water from beds of sandstone totalling more than 100 ft., but, as they ended off some 5 ft. above the thickest band, two borings (4 in. diameter and 14 and 38 ft. deep respectively) were completed in April, 1909, from the bottom of the first shaft into the thick sandstone. This effected an increase of nearly 100,000 gallons per day. In September, 1909, there was again evidence of diminution, so two more borings—which further increased the supply—were made in 1911.

It soon became apparent, however, that the supply in the 100-Feet Sandstone was becoming exhausted by pumping and was not being properly augmented by rain finding its way down into the rock. In consequence, F. C. Cook, the then Borough Surveyor, advised the Council that he did not consider it safe to rely on obtaining from this source a permanent supply of more than 500,000 gallons per day.

The working of the 9-Feet Slate Coal, some 480 ft. below the bottom of the well and subsequently of the ' Two Yard ' seam some 390 ft. below, caused subsidence and damage to the well and Pumping Station which has been well described by F. C. Cook and R. C. Moon.[1]

ANALYSES.

Whittleford Well in lower part of Keele Beds and Halesowen Group (Upper Coal Measures). Analyses by Messrs. Bostock Hill and Rigby, Birmingham.

1, 2, 3, & 4, Unfiltered water from well. (1) 6.1.11 ; (2) 9.1.11 ; (3) 24.7.17 ; (4) 22.8.18.
5. Filtered water from tap at Council Offices, Nuneaton. 5.1.11.
6. Water from brook at Whittleford. 9.1.11.

Parts per 100,000

	1	2	3	4	5	6
Free and saline ammonia	0·006	—	·004	·005	trace	
Organic ammonia ...	0·004	—	·006	·004	·006	
Chlorine in chlorides ...	2·6	—	2·9	3	2·6	
Nitrogen in nitrates and nitrites	trace	—	·08	·33	trace	
Oxygen absorbed in 4 hrs.	0·022	—	·032	·002	·01	
Total solid matter... ...	49	—	51	50	50	
Appearance	Reddish and turbid	Reddish and turbid	Turbid	Turbid	Pretty clear	
Oxides of iron and alumina	2·6	1·820	—	—	·4	1·82
Calcium oxide	13·757	9·630	—	—	13·7	16·31
Magnesium oxide	3·083	2·158	—	—	2·86	2·88
Sulphuric acid	11·314	7·920	—	—	11·314	12·67
Chlorine	2·6	1·82	—	—	2·6	3·22
Nitrogen	trace	trace	—	—	trace	·55
Carbonic acid	5·657	3·96	—	—	4·587	4·22
Hardness : temporary ...	14·143	9	19·1	17·3	10·428	9·62
permanent ...	17·143	12	16·0	13·7	18	17·38
total ...	31·286	21	35·1	31·0	28·428	27

CLARA WELL, GRIFF.

In a field to the west of the Clara Pit of the Griff Colliery.

Well (14 ft. in diameter) :

[For section see record of Clara Boring] ... 270 ft.

Headings at bottom in 100-Feet Sandstone.

No. 1.—17 yds. A little water tapped.

No. 2.—12 yds. At right angles to the dip of the Coal Measures, almost due south. Several good feeders intercepted.

No. 3.—18 or 19 yds. Several good feeders intercepted.

Yield.—Disappointing and has never exceeded 15,000 gallons per hour. Water-level.—Standing, 141 ft. ex surface. Quality. —Analyses, p. 108. The water contains some iron, so two 8 ft.

[1] *Trans. Inst. Water Eng.*, vol. xxv (1921), pp. 176-190.

diameter Candy Pressure Filters were installed as the aëration of the water, which is necessary for the oxidation of the iron, is performed within the filters themselves. This source of supply was discontinued at the end of 1925.

Clara Boring. Made in a field to the west of the Clara Pit of the Griff Colliery in 1909-10 and particulars communicated by Messrs. Duke and Ockenden, Ltd. Surface-level, 359ft. above O.D.

		Thickness	Depth	
		Ft.	Ft.	Notes.
Halesowen Group	Yellow clay	15	15	
	Mottled clay	10	25	
	Blue clay	10	35	
	Red clay	6	41	
	Red and blue clay	3	44	
	Mottled clay	13	57	
	Blue clay	4	61	
	Brown clay	15	76	Index *Spirorbis* —Limestone
	Limestone	22	98	
	Black clay	1	99	
	Blue clay	31	130	
	Soft sandstone	11	141	
	Hard sandstone	35	176	
	Soft blue clay	5	181	
	Hard blue clay	24	205	
	Sandstone	17	222	100-Feet Sandstone (upper part)
	Soft sandstone	3	225	
	Hard sandstone	2	227	

Water-level, 64 ft. ex surface. Yield.—Tested to 400 gallons per hour. Supply from 100-Feet Sandstone.

In a Report Prof. Charles Lapworth said :—" The old Griff Collieries are sunk through the lowest layers of the 100-Feet Sandstone, down into the 4-Feet Sandstone, and the quantity of water yielded has been fairly large from the first. In 1892 the Company sunk two shafts—the Clara Pit and the Marion Pit—half a mile to the west of their former shafts. These shafts passed completely through the 100- and 4-Feet Sandstones. During the whole of the period of sinking 1,000 to 1,200 gallons per minute were pumped from the 100-Feet Sandstone. When the 4-Feet Sandstone was reached 150 ft. below this, the total quantity of water increased to 1,300 gallons per minute, bringing the yield up to 1,812,000 gallons per day. The 4-Feet Sandstone was thus comparatively dry here."

Analyses.

Clara (Trial) Boring and Permanent Well, Griff.

1. From borehole after 24 hrs. pumping. 23.12.09.
2. ,, ,, ,, 48 hrs. ,, 24.12.09.
3. From well at a depth of 67 yds. 16.8.11.
4. ,, ,, ,, ,, ,, 82 yds. during 14 days pumping test
5. Unfiltered water, Well. 15.7.15.
6. ,, ,, ,, 7.1.16.
7. Filtered water from Candy Filters. 15.7.15.

Analyses made by Messrs. Bostock Hill and Rigby, Birmingham.

Parts per 100,000

	1	2	3	4	5	6	7
Free and saline ammonia	·009	·009	·008	·008	·009	trace	·007
Organic ammonia	·002	·002	·011	·004	·007	·005	·006
Chlorine in chlorides	3·8	3·9	3·1	3·6	3·9	4	4·05
Nitrogen in nitrates and nitrites	0	trace	0	·220	0	0	0
Oxygen absorbed in 4 hrs. at 80°F.... ...	·084	·084	·116	·008	·115	·030	·035
Total solids dried at 100°C.	68	68	40	66	84	80	88
Hardness: temporary	10·62	10·62	10·30	12·8	16·7	17·8	16·3
permanent	16·00	16·00	15·40	21·4	30·7	24·9	32·9
total	26·62	26·62	25·70	34·2	47·4	42·7	49·2

Remarks :—

1, 2. Brown and turbid due to iron in suspension.
3. Slightly turbid.
4. Brownish precipitate due to iron.
5. Turbid—iron (= ·60).
6. Bright, contains many small particles.
7. Slightly opalescent, containing many small particles. Faint trace of iron.

The mineral matter in a sample of unfiltered water, in parts per 100,000, was :—

Calcium carbonate	19·1
,, sulphate	14·95
Magnesium ,, ...	20·75
Sodium ,, ...	7·25
,, chloride	6·25
,, nitrate	·25
Oxide of iron, silica, etc.	2·45
	71·00

Analysis of water from Clara Well, Griff, made by Dr. J. C. Thresh and J. F. Beale, The Counties Public Health Laboratories, London. 7.10.1915. Filtered through Candy Filters.

Turbidity : Yellowish, no deposit of oxycarbonate of iron.

Colour : Yellow tint. Odour : None. Reaction : Neutral.

[See next page.]

Chemical Examination

Results expressed in parts per 100,000

Ca	Mg	Fe	Na	CO_3	SO_4	Cl	NO_3
12·0	4·2	·86	4·87	11·5	32·0	3·8	·18
7·6	—	—	—	11·5	—	—	—
4·4	—	—	—	—	10·55	—	—
—	4·2	—	—	—	16·55	—	—
—	—	—	2·35	—	4·9	—	—
—	—	—	2·45	—	—	3·8	—
—	—	—	·07	—	—	—	·18
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—

Probable combinations.	
Calcium carbonate	19·1
Calcium sulphate	14·95
Magnesium sulphate	20·75
Sodium sulphate	7·25
Sodium chloride	6·25
Sodium nitrate	·25
Oxide of iron, silica, etc.	2·45
Total solids dried at 180°C.	71·0

Hardness: Temporary, 15°; Permanent, 33°; Total 48°

Free ammonia	0·0080
Organic ammonia	0·0042
Oxygen absorbed in 3 hours at 37°C. ...	0·0800
Nitrites	absent

In 1919 the Nuneaton Town Council sought powers to sink a well and erect a Pumping Station on the north-west side of the road near Hollyfast Farm, in the parish of Allesley, a little less than a mile southward of Corley ; to construct a main from the Pumping Station to a service reservoir near the Schools at Corley ; and to lay a main *via* Astley Court and How Green to the existing Pumping Station and Filters at Robinson's End.

The well was to be in the Corley Sandstones and Conglomerates (Enville Group) just to the north of a fault which, by bringing impervious beds into juxtaposition with the pervious (fissured) Corley beds, produces a natural dam. The site is 2,750 yds. from the Watery Lane Pumping Station, and 2,133 yds. from the Corley Pumping Station of the Coventry Corporation Waterworks. The wells at the latter and at the Spon End Pumping Station of the same Corporation are in Corley Sandstones and Conglomerates. As it was rightly feared that additional pumping from the Corley beds would reduce the available supply to Coventry the Nuneaton Council's application was refused and the Council subsequently made arrangements with the Leicester City Council to augment their supply from the Thornton Reservoir.

Midland Quarry Well.

Well (collecting quarry-water) in Hartshill Quartzite (Cambrian). See p. 5.

Haunchwood Colliery

Tunnel Pits. In a Report Prof. Charles Lapworth said :— " The shaft is sunk down to the Slate Coal and is 1,050 ft. in depth.

" At 100 ft. below the surface the 40-Feet Sandstone was met with and proved to be 37 ft. 6 ins. in thickness. It yielded a little water but none of any consequence. At a depth of 285 ft. the *Spirorbis*-Limestone was encountered.

" At 360 ft. below the surface the 100-Feet Sandstone was entered and found to be about 150 ft. thick [162 ft.[1]]. About half-way down its depth it was found to be rich in water yielding 200 gallons per minute (or 288,000 gallons per day).

" Between 700 and 800 ft. from the surface the 4-Feet Sandstone was cut but yielded no water.

" The negligible yield of the 40-Feet Sandstone suggests either that the Robinson's End Well takes the water or that the Sandstone is too hard to yield much water unless opened by headings as in the case of the Robinson's End Well.

" The yield of the 100-Feet Sandstone was 288,000 gallons per day during the sinking, but by October, 1895, had fallen to 70,000 gallons a day or less than one-third of what it was at first, but this yield is said to be constant.

[1] ' Coventry Memoir,' p. 75.

" The outcrop of the 100-Feet Sandstone is one mile to the north-east of the Tunnel Colliery shaft. As the same bed at Morris and Shaws and Baxterley (near the outcrop of the bed) yielded from 400,000 to 700,000 gallons daily, it is apparent that the yield of the bed *decreases* by more than *one-half* of its amount *per mile* as the outcrop is receded from. Also, that the *constant yield* is less than *one-third* of the original amount."

Brewery Well.

Nuneaton, centre of the town. The Brewery (Knowles and Co.) has been demolished and the site is occupied. Particulars communicated by Messrs. John Knowles and published in *Rep. Brit. Assoc.* for 1875, p. 135. Repeated and remarks added by [Sir] A. Strahan, *Geol. Mag.*, 1886, p. 555. Surface level 267 ft. above O.D.

Well (30 ft. deep and 8 ft. in diameter ; borehole 82 ft. deep and 4 in. in diameter) :

		Thickness Feet	Depth Feet
[Alluvium and ? Glacial Deposits	Drift (sand, gravel, and clay)	18	18
[Keuper Marl]	Red marl	12	30
[Lower Keuper Sandstone]	Lower Keuper Sandstone	80	110
[Probably Hartshill Quartzite]	Permian (or Carboniferous)	2	112

Drift waters kept out of the well by tubbing. Rest-level.—Standing, 7 ft. ex surface. The rest-level did not vary with the seasons more than 3ft. at the most : it stood permanently 5 ft. above the level of the River Anker. Quantity capable of being pumped in gallons per day.—250,000 gallons. Quality of water.—Hard [but pure]. According to A. Strahan the 2 feet of rock classified above as Permian (or Carboniferous) was " Hard slaty white rock."

The White Stone Well.

Site marked B.H. on Geological Survey map, New Series, Sheet 169. Near White Stone Farm. Section communicated by W. Andrews to [Sir] A. Strahan and published by the latter in *Geol. Mag.*, 1886, p. 554. Referred to by W. Andrews in *Proc. Warwickshire Nat. and Arch. F. C.* for 1886, pp. 31, 32, and for 1906, p. 10. Surface-level 323 ft. above O.D.

Well (80 ft. deep and 6 ft. in diameter ; borehole 50 ft. deep) :

		Thickness Feet	Depth Feet
[Lower Keuper Sandstone]	White sandstone and red shale	60	60
[Cambrian. Stockingford Shales]	Hard mottled blue and purple shales	70	130

Rest-level.—About 20 ft. below surface-level. Yield, 40,000 gallons per day. This well was made by the Hinckley Corporation in 1886, but the quantity of water obtained was insufficient for the needs of Hinckley.

ANALYSIS.

Sample drawn at 59 ft. level. 26.11.21.

	Parts per 100,000
Free and saline ammonia	0·001
Organic ammonia	0·004
Chlorine in chlorides	3·3
Nitrogen as nitrates and nitrites	none
Oxygen absorbed from permanganate at 80°F. in 4 hrs	0
Total solids dried at 100°C.	50
Hardness : temporary	15·78
permanent	11·14
total	26·92

Appearance.—Turbid, very many small particles.

Atteborough

On the east side of the railway about 750 yds. west of The White Stone trial well and boring, Mr. T. S. Stooke reported :[1] " There are indications . . . of an ample supply of water. I am informed that some years ago a bore-hole was put down to test the quality of the stone [Lower Keuper Sandstone], and that water overflowed from it at the surface, consequently the hole had to be plugged."

ROYAL LEAMINGTON SPA BOROUGH

The general ' solid ' geology of the Borough is represented on the Geological Survey map, Old Series, Sheet 53 N.W. When it comes to be revised no doubt differences in detail will be found. As the general geology is dealt with under the sub-heading ' Geological Source of Medicinal Waters ' (p. 128), it is unnecessary to discuss it here.

Corporation Waterworks

Supply Royal Leamington Spa Borough, 6,749 out of 6,751 houses.

Sources of Supply :—

(1) Campion Terrace Well and Headings ;
(2) Lillington Well and Headings.

The average daily quantity of water available from each source is, respectively :—(1) 684,000 gallons ; (2) 528,000 gallons. Analyses, p. 117.

CAMPION TERRACE WELL AND HEADINGS.

The main and pilot wells and borings (not now functioning) have occasionally been described as the ' Leicester Street ' wells and boreholes. They were made in 1875.

[1] ' Report, with Plan, on Hinckley Water Supply,' 31st March, 1884. *Shrewsbury*. [Privately printed.]

From : C. Twamley, *Proc. Warwickshire Nat. and Arch. F. C.* for 1878, pp. 32, 33 ; see also pp. 17, 18 (called the ' Leicester Street Boring ').

See also [Henry] Bright in *Rep. Brit. Assoc.* for 1876, p. 97 ; G. B. Jerram, *Rep. Brit. Assoc.* for 1880, pp. 95, 96 ; L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 300.

Height above O.D., 213 ft.

Shaft (110 ft., 20 ft. diameter) and borehole (silted up for 25ft.):—

			Thickness		Depth	
			Ft.	In.	Ft.	In.
[Keuper Marl and ' Passage Beds '.]	1.	Red clay	3	0	3	0
	2.	Red marl	7	0	10	0
	3.	Grey marl in streaks ...		6	10	6
	4.	Red marl	2	6	13	0
	5.	Grey rag rock	1	0	14	0
	6.	Red rock marl	6	0	20	0
	7.	Red rock (hard)	1	0	21	0
	8.	Grey rag rock (like sandstone)	2	6	23	6
	9.	Grey marl or blue bind ...	1	6	25	0
	10.	Red rock marl	2	0	27	0
	11.	Red rock (hard)	1	0	28	0
[Lower Keuper Sandstone]	12.	Grey red rock (very gritty)...	3	0	31	0
	13.	Red rock		6	31	6
	14.	Grey rag rock (approaching freestone)	2	6	34	0
	15.	Hard sandstone rock (with water)	8	0	42	0
	16.	Sandstone rock in layers about 1 ft. each, with ½ in. to 1 in. of blue bind and at each layer fresh springs of water	7	6	49	6
	17.	Sandstone with a few specks of white of a chalky nature		6	50	0
	18.	Hard sandstone	3	0	53	0
	19.	Soft sandstone	1	0	54	0
	20.	Hard sandstone	5	0	59	0
	21.	Quick sand		1	59	1
	22.	Softish sandstone	2	5	61	6
	23.	Soft red marl		6	62	0
	24.	Hard red sandstone ...	2	0	64	0
	25.	Layers of blue bind and sandstone	2	0	66	0
	26.	Soft sandstone	4	0	70	0
	27.	Hard brown rag sandstone...	4	6	74	6
	28.	Hard rag rock	3	6	78	0
	29.	Sandstone	8	0	86	0
	30.	Red marl	1	0	87	0
	31.	Sandstone with water ...	5	0	92	0
	32.	Red sandstone	1	9	93	9
	33.	Blue bind		3	94	0
	34.	Hard white sandstone with streaks of blue bind ...	19	0	113	0
	35.	Blue bind		4	113	4
	36.	White sandstone	2	8	116	0

			Thickness Ft.	In.	Depth Ft.	In.
[? Enville Group.]	37.	Red marl		6	116	6
	38.	Sandstone (reddish)	2	6	119	0
	39.	Red marl		6	119	6
	40.	Sandstone (reddish)	2	6	122	0
	41.	Red marl		6	122	6
	42.	Sandstone	2	0	124	6
	43.	Red marl		6	125	0
	44.	Sandstone (reddish) ...	2	6	127	6
	45.	Red marl	1	0	128	6
	46.	Hard red sandstone ...	8	6	137	0
	47.	Red marl	1	0	138	0
	48.	Hard yellow sandstone ...	13	0	151	0
	49.	Hard red rock	2	6	153	6
	50.	Red marl		6	154	0
	51.	Hard red rock	4	6	158	6
	52.	Red marl		6	159	0
	53.	Red sandstone	3	0	162	0
	54.	Red marl	2	0	164	0
	55.	Hard red rock	7	0	171	0
	56.	Hard red sandstone ...	1	0	172	0
	57.	Very hard red sandstone ...	1	0	173	0
	58.	Red marl		6	173	6
	59.	Very hard red sandstone ...	5	0	178	6
	60.	Red marl		6	179	0
	61.	Ordinary red sandstone ...	1	6	180	6
	62.	Red marl	3	0	183	6
	63.	Very hard red sandstone ...	11	6	195	0
	64.	Red marl		6	195	6
	65.	Ordinary red sandstone ...	6	6	202	0
	66.	Similar beds : about ...	32	6	234	6
	67.	Soft marl : about	8	0	242	6

From the bottom of the well two headings have been driven of which the following are particulars :—

	(1)	(2)
Direction	N.W. by W.	
Length	636 ft.	
Cross-section : height ...	7 ft.	7 ft.
breadth ...	5 ft.	5 ft.
Depth from surface to roof	103 ft.	103 ft.
Year in which made ...	To 200 ft. in 1886 to 400 ft. in 1894 to 636 ft. in 1922	1926

Rest-levels : original, 1879 below surface ... 20 ft.
August, 1881 ,, ,, ... 66½ft.

Quantity of water pumped in 7½ hours : 467,170 gallons. The bulk of the water comes from fissures in the sandstone—bed 34.

Lillington Well and Headings.

Made in 1888. Particulars communicated by W. de Normanville, Borough Surveyor. 13.11.1905.

Summarized record published by L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 300.

Height above O.D. 315·5 ft.

Well (diameter 8 ft.) :—

			Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Drift.]	1.	Soil	1	6	1	6
	2.	Clay	3	6	5	0
	3.	Wet sand	4	6	9	6
	4.	Red marl	16	0	25	6
	5.	Sand	13	6	39	0
	6.	Running sand	9	0	48	0
[Keuper Marl]	7.	Marl	2	6	50	6
	8.	Soft marl	20	0	70	6
	9.	White marl	1	0	71	6
	10.	Hard marl passing down into				
	11.	Very hard marl	24	0	95	6
[Lower Keuper Sandstone]	12.	White sandstone	8	0	103	6
	13.	Red marl	3	0	106	6
	14.	White sandstone	4	0	110	6
	15.	Streaky marl...	1	6	112	0
	16.	White sandstone	10	6	122	6
	17.	Red marl	6	6	129	0
	18.	White sandstone	26	0	155	0
	19.	Hard red stone	2	0	157	0
	20.	White sandstone	3	6	160	6
	21.	Marl	1	0	161	6
	22.	White sandstone	6	0	167	6
	23.	Marl		6	168	0
	24.	White sandstone	13	3	181	3
	25.	Marl	1	3	182	6
	26.	White sandstone	9	6	192	0
[?Enville Group]	27.	Marl	3	0	195	0

From the well are headings (the New below the Old) of which the following are particulars :—

Direction		S.W. by W.	S.E.
Length :	Old	100 ft.	110 ft.
	New	260 ft.	183 ft.
Height :	Old	6½ ft.	6½ ft.
	New	6½ ft.	6½ ft.
Breadth :	Old	4 ft.	4 ft.
	New	4 ft.	4 ft.
Depth from surface to roof of—			
Old heading : about		163 ft.	163 ft.
New heading : about		188 ft.	188 ft.

		Below surface
Water-levels :	Original.—Rest level	135 ft.
	After pumping 9 hrs. ...	169 ft.
	Present. —Rest level	165 ft.
	After pumping 14½ hrs. ...	192½ ft.

Yield, 458,500 gallons per 24 hours.

Analyses.

Analyses made by Messrs. Bostock Hill & Rigby, 11th November, 1924 and communicated by J. J. Kennan, Borough Surveyor. (1) Campion Terrace, (2) Lillington.

	Parts per 100,000 (1)	(2)
Free and saline ammonia	0·0015	trace
Albuminoid ammonia	0·006	trace
Chlorine in chlorides	3·5	1·7
Nitrogen in nitrates and nitrites	trace	0·165
Oxygen absorbed from permanganate at 80°F. in 4 hours	0·005	0·002
Total solids dried at 100°C.	70	37·5
Hardness : Temporary	15·0	11·2
Permanent	32·1	16·0
Total	47·1	27·2

Remarks :—

Campion Terrace.—Slightly opalescent, few small particles.

Lillington.—Bright, few small particles.

Sewage Works Boring.

Trial boring made by Messrs. Docwra & Sons in 1872-73 on site of present Sewage Works. Particulars communicated by the Leamington Board of Health and published in *Rep. Brit. Assoc.* for 1878, p. 388.

A similar section—but with the addition of particulars of the occurrence of water (given in parentheses below) was published by C. Twamley, *Proc. Warwickshire Nat. and Arch. F. C.* for 1878, p. 31. Summarized record published by L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 299. Height above O.D. 161 ft.

			Thickness Ft.	In.	Depth Ft.	In.
[Alluvial]	1.	Made ground	5	0	5	0
	2.	Blue sand	5	0	10	0
	3.	Sandy red clay	5	0	15	0
[Keuper Marl]	4.	Red marl and water ...	6	0	21	0
	5.	,, marl	101	0	122	0
	6.	Light blue marl	6	0	128	0
	7.	Red marl	2	6	130	6
[Lower Keuper Sandstone]	8.	,, sandstone	3	6	134	0
	9.	Light blue marl (salt water at the bottom)	1	6	135	6
	10.	Red sandstone	12	0	147	6
	11.	Grey sandstone (large quantity of fresh water)	26	0	173	6
	12.	Red marl	5	0	178	6
	13.	,, sandstone	9	0	187	6
	14.	Grey sandstone	3	0	190	6
[? all Enville Group]	15.	Rock	1	6	192	0
	16.	Red rock and gypsum ...	4	6	196	6
	17.	Blue marl	4	0	200	6
	18.	Red marl	1	6	202	0
	19.	,, sandstone	3	6	205	6
	20.	,, marl	1	6	207	0
	21.	,, marl and rock ...	1	6	208	6

			Thickness Ft.	In.	Depth Ft.	In.
[? all Enville Group]	22.	Red sandstone	2	0	210	6
	23.	,, marl	2	0	212	6
	24.	,, sandstone	3	0	215	6
	25.	,, marl	1	6	217	0
	26.	,, sandstone	10	0	227	0
	27.	,, marl	2	0	229	0
	28.	,, marl and rock ...	7	6	236	6
	29.	,, sandstone	4	0	240	6
	30.	,, marl	13	0	253	6
	31.	,, sandstone (with fresh water)	1	0	254	6
	32.	,, marl	47	0	301	6
	33.	,, sandstone (with salt water)	9	0	310	6
	34.	,, marl	35	6	346	0

Result.—Abandoned owing to the occurrence of salt water.

LEAMINGTON SPA STEAM LAUNDRY BORING. (Hitchman Road).

Made in 1891 by E. Margrett, Engineer, Reading, and particulars communicated by C. J. Williams, Banbury. Height above O.D., about 202 ft.

Boring (diameter, 6 in.) :—

		Thickness Ft.	In.	Depth Ft.	In.
[Keuper Marl]	Made ground	2	6	2	6
	Mottled red clay	8	6	11	0
	Red marl with pebbles[1] ...	29	3	40	3
	Soft blue rock		9	41	0
	Light-green sandy clay ...	8	6	49	6
	White rock	1	3	50	9
	Red marl clay	6	3	57	0
	Mottled red and green sand ...	8	0	65	0
	Grey rock		9	65	9
	Red marly clay	16	0	81	9
	White sandy clay	2	0	83	0
	Grey rock	2	0	85	0
	Mottled red and green clay ...	3	0	88	0
	Mottled light red and green sand, fine	3	0	91	0
	Light blue clay with layer of grey rock	4	0	95	0
	Light blue sandy clay with two layers of rock	4	0	99	0
	Grey sandstone	2	0	101	0
	Red rock...	1	9	102	9
	Red sandy marl...	5	0	107	9
	Light blue clay	7	0	114	9
	Grey sandstone with beds of sand	2	0	116	9
	Red sandstone	3	3	120	0
	Red marl	3	0	123	0
	Red clay, stiff	1	3	124	3
	Red sandy marl...	1	6	125	9
	Light blue clay	1	0	126	9
	Red marl	12	3	139	0

[1] As far as can now be ascertained there is only a sprinkling of gravel on this site : the term ' pebbles ' here may be descriptive of some other rock-formation not strictly ' pebbles.'

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Lower Keuper Sandstone]	Grey rock with sandy beds and water	14	3	153	3
	Light green sand with nacreous grains	2	6	155	9

Result.—Large supply of saline water : too saline to use.

Leamington Brewery Well.

According to Messrs. Lucas & Co., Ltd., the well and borehole were made about 1840 (Brewery erected 1839), and were deepened in 1898. Height above O.D. about 210 ft.

Well (about 100 ft. deep ; diameter, top, 5 ft. ; bottom, 8 ft.) and borehole (about 100 ft. deep ; diameter, 6 in.) :—

[Lower Keuper Sandstone and ? Enville Beds.]	Hard sandstone with layers of soft sand and clay : about	200 ft.

Water-level (standing), 48 ft. below the surface.

C. Twamley mentions a well and boring at Lewis Haddon & Co.'s Brewery, Lillington Road, "about a mile and a half north-east from the Leicester Street [Campion Terrace Water-] works".[1] He gives the depth of the well as 27 ft. ; and of the borehole 153 ft. —total 180 ft., and says that the supply was "very great", the water rising to within 17 ft. of the surface. Probably he was referring to Messrs. Lucas & Co's. well and bore which were deepened subsequently.

Analysis.

Water from Lower Keuper Sandstone and ? Enville Group. Analysis made and communicated by Messrs. Lucas & Co.

	Grains per gallon.
Total solid residue dried at 212°F.	30·24
Saline residue	28·25
Organic volatile matter and water of crystallization	1·99
Lime	9·33
Magnesia	3·37
Soda	1·22
Potash	trace
Sulphuric acid	5·00
Nitric acid	nil
Nitrous acid	nil
Chlorine	1·40
Poisonous metals	nil
Iron	slight trace
	Parts per million.
Free ammonia	0·01
Albuminoid ammonia	0·03

[1] *Proc. Warwickshire Nat. and Arch. F.C., for* 1878, p. 18.

Mineral Waters[1]

Leamington Mineral Waters are obtained at the present time (June 1925) from three sources, namely :—

1. The New Well, in Jephson Gardens (2 on map) ;

2.—The Original Spring (3)—' Camden's Well ' ;

3.—The Alexandra Fountain, under the L.M. & S.Rly. bridge in the High Street (9).

At the present time the New Well is the sole source of supply to the Royal Pump Room and Baths. From the analysis (p. 132) it will be seen that the New Well water is mainly a Sodium Chloride water. It contains also, however, small quantities of Magnesium Sulphate (Epsom Salts) and Magnesium Chloride.

The Original Spring water contains about twice as much Magnesium Sulphate as that of the Spa New Well.

The Alexandra Fountain water contains Iron, Sodium and Magnesium salts, and is therefore a useful Iron-Saline Water.

[1] For detailed history and account *see* L. Richardson, ' Royal Leamington Spa Medicinal Waters,' *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 2 for 1925 (1926), pp. 161-178.

FIG. 4.—*Map to show positions of Medicinal 'Springs', etc., at Royal Leamington Spa.*

1.—Royal Pump Room and Baths.
2.—New Well.
3.—The Original Spring
4.—The Original (Abbotts's) Well.
5.—Read's Well.
6.—The Imperial Fount (Smart's Well).
7.—Leamington Spa Steam Laundry.
9.—The Alexandra Fountain (Wise's Well).
10.—Site of Old Mill (demolished 1899).
11.—Robbin's Well (Victoria Baths).

SUMMARY OF PARTICULARS OF ROYAL LEAMINGTON SPA MEDICINAL SPRINGS.

Name	No. on map, p. 122	Year in which sunk.	Depth (in feet)	Other Names of 'Springs,' Owners, etc.	Present Description of Site	Years in which Baths were opened and closed
The Original Spring ...	3	—	—	Original, Old, Public, and Lord Aylesford's Well.	—	—
The Original (or Abbotts's) Well	4	1786	21	Abbotts's, Mrs. Smith (Abbotts's daughter), Wm. Smith (Abbotts's grandson), J. Goold, Wood. 'Center Well' (of Field).	Messrs. E. Francis & Sons, Ltd., Bath St.	Baths opened 1788. Closed 1867.
(Matthew) Wise's Well...	9	1790	42	Curtis. Also occasionally known as the 'Road Well.'	Alexandra Fountain and vicinity, High Street.	Baths demolished 1846.[1]
F. Robbins's Well ...	11	1806	20	Victoria Baths 'Bridge Well.'	Victoria Colonnade.	Baths opened 5 July, 1806. Closed before 1841.
(Rev. W.) Read's Well...	5	1806	60	Mr. Smith, Mrs. Lee,—York, James Hudson.[2] 'South Well.'	London Road Garage next door to the Crown Hotel, High St.	Baths opened 1806. Closed about 1881
Royal Pump Room Wells	1	1806	34	'North Well.' 'Old Well.'	Royal Pump Room and Baths.	Baths opened 1819.
Imperial Fount (and Marble Baths)	6	1816	70 (nearly)	Smart, Fairweather (succeeded Smart in 1827).	Messrs. Sleath's Ltd., Clemens St.	—
New Well	2	1902	52	(Now the Spa Well)	Between lodge and River Leam close to the N.E. end of the Victoria Bridge but in Jephson's Gardens.	—

[1] Water from well laid on to Alexandra Fountain in 1863. [2] Bought by James Hudson in 1858.

The Original Well.—The sinking of the first well with the express object of obtaining ' Leamington Waters ' is said to have been brought about as follows :—A certain William Abbotts possessed a piece of ground opposite (west of) the Original Spring. He had long wished to discover another spring and had had wells sunk, but without success. On 14th January, 1784, he was telling Benjamin Satchwell—a village worthy—of his desire, when Satchwell suddenly observed a spring bubbling up in a brook near by.[1] Satchwell tasted the water and found that it was saline. He had a sample taken, evaporated it, and sent the residue to a Dr. Kerr of Northampton. Dr. Kerr examined the water, spoke highly of it, and advised Abbotts to sink a well (4). This Abbotts did in 1786 : ". . . a rock was found at a distance of eighteen feet, and within this rock, at the depth of three feet, rises the water . . ."

Under Dr. Kerr's patronage Abbotts erected the first (' Original ') baths in Leamington, which were opened in June, 1788. In 1815 they were rebuilt and enlarged. In the Table, page 123, will be found the names of the successive proprietors, etc. The Baths were closed in 1867, when they were bought by Messrs. E. Francis & Sons, Ltd., and " the semicircular plate glass window at the corner of Bath Street and Smith Street encloses [in 1901, and still does] the site [of the Original or Abbotts's Well]."[2]

Wise's Well.—In 1790, a third ' spring ' (9) was discovered : ". . . in the high road[3] from Warwick to Southam and London, [on ground] the property of Matthew Wise Esq."

In ' Moncrieff's Guide to Leamington Spa . . .' it is stated :[4]— " The water of this spring was found at the great distance of forty-two feet from the surface of the ground. A well was first sunk to the depth of twenty-four feet. In the course of that depth a rock presented itself, which was nearly ten feet in thickness, followed by a bed of marl, and after that, a rock much harder than the former ; through this second [rock] a bore was made, eighteen feet deep, when a cleft was found, through which a copious supply of the mineral water is procured. Handsome and commodious baths were immediately erected in Bath Street and the Royal Parade, near the site of this well, . . ." Wise's Well and Baths later became Curtis's Well and Baths ; but the Baths were demolished in 1846 to make way for the L. & N.W. Ry. (now the L.M. & S. Ry.). In 1863 the water from the well was piped to the Alexandra Fountain, which was erected by public subscription.

The sinking of Abbotts's Well in 1786, some sixty yards away from the Original Spring, is said to have caused, in 1800, the level of the water at the Original Spring to fall several feet.

[1] Dr. A. B. Granville, in his ' Spas of England, etc., Midland Spas ' (1841), p. 234, said that the spring Satchwell saw was the " Original Spring "—Camden's Well.

[2] Dudley, T. B., ' Complete History of Royal Leamington Spa, . . . ' (1901), p. 78.

[3] Hence the name by which it was occasionally known—the ' Road Well.'

[4] 4th ed. (1829), pp. 26, 27.

Various buildings have occupied the site: the present (1927) 'Old Well House' dates from 1891 and is open to all who care to enter and take the water—free.

Robbins's Well.—In 1806 a fourth 'spring' (11) called Robbins's Well, after its proprietor, was discovered close to the south-west end of the present Victoria Bridge over the River Leam and under the present Victoria Colonnade.

"In sinking this well, the workmen first dug through a bed of blue clay, or marl, after which two or three thin strata of sandstone successively presented themselves, increasing in thickness as they went on. Passing these, a solid rock came into view, which being struck into, poured forth a body of strong saline water, that soon nearly filled the well. The depth of this rock, it is supposed, is about twelve feet below the surface, so that, altogether, the water was found at a depth of twenty feet only".[1]

Baths—later known as the Victoria Baths—were erected and opened on 5th July, 1806, but were closed at the time of Dr. A. B. Granville's visit about 1841. For a time the water from this well was pumped through a pipe under the River Leam to the Royal Pump Room, but disconnection was effected about 1903.

Read's[2] *Well.*—The year 1806 saw the discovery of a fifth 'spring' (5) on the site now (1927) occupied by the London Road Garage adjacent to the Crown Hotel in High Street, and then practically opposite Curtis's Baths.

C. Twamley said in 1878[3]:—"The next spring [Read's], now [1878] called Lee's Baths, is 60 feet deep. After passing through gravel, in which is a spring of fresh water, is a bed of marl 8 feet thick, succeeded by a white clay and sandstone, in which water of a brackish taste was found. Next succeeded a hard rock, 28 feet thick; next a bed of softer stone, followed by another marl, below which the water rises."

Royal Pump Room Wells.—Towards the close of 1806[4] a sixth 'spring'—the Royal Pump Room or 'North Well' spring (1)—was discovered: this time, be it noted, to the north of the River Leam, at a depth of 34 ft. According to Dr. C. Loudon ". . . two different kinds of water were found to exist"[5]—the saline water, and in a shallower well, one charged with sulphuretted hydrogen.

According to J. J. Kennan, Borough Surveyor (1925):—"There are now two disused wells under the Royal Pump Room. In 1900 one was cleaned out (having been filled in some 35 years earlier), and the water tested, but was pronounced as no good, its strength in minerals being only $\frac{1}{8}$ to $\frac{1}{6}$ of standard water and in no sense a sulphur water."

[1] "Moncrieff's Guide to Leamington Spa . . ." (4th ed., 1829), p. 27.
[2] Sometimes erroneously spelt 'Reid's.'
[3] *Proc. Warwickshire Nat. and Arch. F.C.* for 1878, pp. 16, 17.
[4] According to some accounts in 1808, to others in 1810.
[5] 'A Practical Dissertation on the Waters of Leamington Spa . . .' (3rd ed. 1831), p. 18.

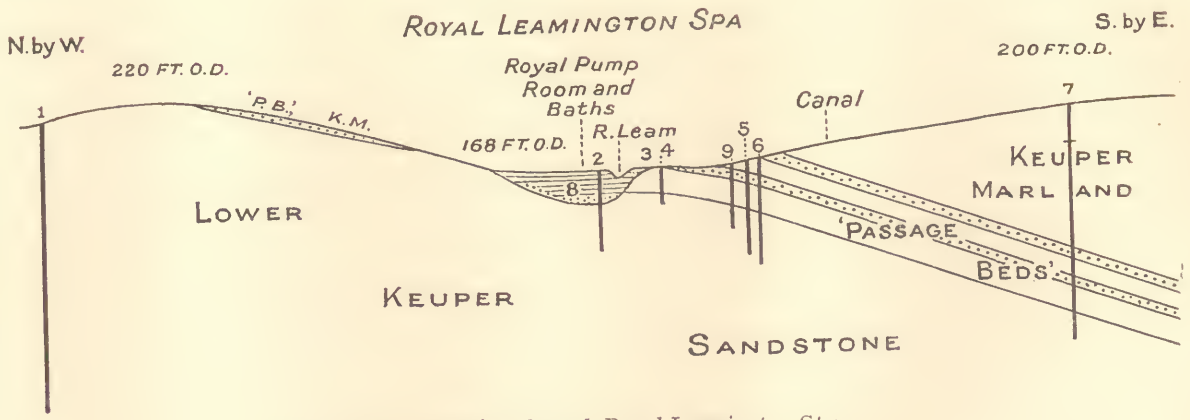

FIG. 5.—*Section through Royal Leamington Spa.*

1.—Leamington Brewery well and borehole (fresh water).
2.—' The New Well '.
3.—' The Original Spring '.
4.—' The Original Well '. (Abbotts's).
5.—Read's (later Hudson's) Well.
6.—Smart's or Imperial Fount Well.
7.—Leamington Spa Steam Laundry borehole (salt water).
8.—Leam-side gravel and alluvium.
9.—Alexandra Fountain well (*olim* Wise's, Curtis's well).

Royal Pump Room New Well. In 1902 the New Well was sunk in the Jephson Gardens, and this, at the present time (1927), is the sole source of supply for the Royal Pump Room and Baths—and the supply is practically unlimited.

Smart's Well.—In April, 1816, a seventh 'spring' (6) known as Smart's Well and also as the 'Bazaar' and 'Imperial Fount', was discovered in Clemens Street, on the premises now occupied by Messrs Sleath's, Ltd., at a depth of nearly 70 feet. Baths were erected by Smart and opened in 1817, and the waters were advertised as "Chalybeate, Saline Aperient, and Sulphurous or Harrowgate Springs."

Dr. C. Loudon wrote[1]:—"Besides the spring which contains the iron in this establishment there are also a pure saline and a sulphureous spring, both of which arise from strata below the ferruginous source".

Dr. A. B. Granville said that the chalybeate water of The Imperial Fount was "the only chalybeate water known in Leamington",[2] but that the establishment was closed at the time of his visit—about 1841.

Dr. Granville also said that the sulphur water was originally found in a well belonging to the next house to the Imperial Fount (in Read's Well); that to form the Imperial Fount a well was sunk which drained Read's Well into that of the Imperial Fount; that arbitration was eventually resorted to but that it ruined the proprietor of Read's Well, while the Imperial Fount people fared little better; and that the establishment was closed at the time of his visit.

A Mrs. Lee, however, Granville recorded, purchased Read's Well and Baths, had the well sunk 15 ft. deeper, and recovered the sulphur water, but the establishment was "but little frequented; and yet I should think the water deserved the attention of the medical men of the place, for many of the cases in which a saline water of considerable power, charged with sulphuretted gas, is required. It approaches nearer to the milder Harrogate and Knaresborough water than any I have yet tasted, and is infinitely superior to the Sulphur water at the Royal Pump Room".[3]

T. B. Dudley said in his 'Complete History of Royal Leamington Spa . . .' (1901, p. 134) that the two qualities of water, saline and sulphurous, at the Imperial Fount came from the *same* well. Between 1816 and 1834 ". . . an additional spring[4] was discovered at the very southern extremity of Leamington, almost further back

[1] 'A Practical Dissertation on the Waters of Leamington Spa . . .' (3rd ed., 1831), p. 19.

[2] 'The Spas of England, etc., Midland Spas' (1841), p. 231.

[3] 'The Spas of England, etc., Midland Spas' (1841), p. 233.

[4] Probably in a well.

[south] than Ranelagh Gardens ; a very splendid suite of baths and pump room were talked of here under the name of the Grand Spa, but have not been persevered in ".[1]

On July 19th, 1838, permission was granted by Queen Victoria to call Leamington—' Royal '.

Geological Source of the Medicinal Waters.—Leamington extends over Lower Keuper Sandstone, Keuper Marl, and—in the vicinity of the River Leam—Alluvium, with occasional layers of peat, and, more particularly at the base, gravel. Gravel and sand (Superficial Deposits) are sporadically distributed over the surface of the ' solid ' rocks, and particularly over that of the Keuper Marl to the south of the River Leam.

The Lower Keuper Sandstone, according to the Geological Survey Map (Old Series) 53 S.W., occurs in an area, in plan, roughly tongue-shaped, with the tip of the tongue in the vicinity of the Leamington Brewery, and the base coincident with the south bank of the Leam between Mill Bridge (Jephson Gardens) and a little east of Adelaide Bridge. The Geological Survey Map shows a narrow outcrop of the Sandstone extending westward of Adelaide Bridge and joining up with the main outcrop to the westward. This may be the case, but if so, the outcrop is narrower than is represented, for Keuper Marl occurs at least up to the bridge that carries the Kenilworth and Coventry Railway (L.M. & S.) over the road into Victoria Park east of the Sewage Works.

The section given on page 126 shows the arrangement of the rocks along a north by west—south by east line, from Leamington Brewery (1) to the Leamington Spa Steam Laundry (7). No reliable information is available as to the thickness of the Lower Keuper Sandstone, but a thickness of about 88 ft. may be suggested. Below the Lower Keuper Sandstone come marls, clays, and sandstones belonging to the Enville Group. The Brewery well and boring probably pierce Lower Keuper Sandstone and Enville Beds.

The Lower Keuper Sandstone and Keuper Marl (including the ' Passage Beds ') have a southerly dip. The top of the Lower Keuper Sandstone was proved to occur below the Leamington Spa Steam Laundry (7 on section) at 139 ft. down. A study of particulars recorded in literature will, it is considered, demonstrate that it is probable that the top of the formation comes as indicated on the section where Smart's (6), Read's (5), Wise's (9) and Abbotts's wells are situate. North of the River Leam the line of section traverses a salient of Keuper Marl according to the one-inch Geological Survey Map (Old Series). Joining the two surface-levels where the marls ' thin out ' a slope is arrived at for the top of the Lower Keuper Sandstone. If this ' slope line ' be extended at about the

[1] ' Moncrieff's Guide to Leamington Spa . . . ' (4th ed., 1829), p. 46.

inclination indicated it will be found to pass close to the point at which the top of the Lower Keuper Sandstone is shown in the Laundry borehole.

The New Well of the Royal Pump Room penetrates Leam-side alluvium and gravel and then enters the Lower Keuper Sandstone. The original wells of the Royal Pump Room penetrate like formations, but the Sandstone not so deeply.

North of the flat alluvial tract bordering the River Leam it is to be noted that wells tap fresh water only.

So generalizing, it may be said that the medicinal waters occur beneath the Keuper Marl in the ' Passage Beds ' and Lower Keuper Sandstone south of the vicinity of the River Leam, but are absent from the practically uncovered tract of Lower Keuper Sandstone to the north.

If the south bank of the River Leam from Mill Bridge to the Sewage Works be studied, the following facts will be observed, namely, that the Lower Keuper Sandstone is to be seen exposed, imperfectly between Mill and Victoria Bridges, and, excellently, for certain distances above and below the footbridge carrying the path from near the Public Library to the Pump Room Gardens, and that it disappears a short distance before Adelaide Bridge is reached —apparently dipping down beneath the Keuper Marl, which, at the Sewage Works, overlies the Sandstone (as proved by a boring) to a thickness of 130½ ft. These facts indicate that the Lower Keuper Sandstone between Mill Bridge and (near) Adelaide Bridge is slightly arched.

There would thus appear to be a slight anticlinal flexure of Lower Keuper Sandstone with an axis pitching south by east, causing the Sandstone to disappear beneath the Keuper Marl to the south of the Leam. The Original Spring—that noticed by Camden—originally issued from a fissure in the Sandstone in the crown of the anticlinal flexure and is—although its ' head ' is now somewhat reduced—an artesian spring.

It is of very common occurrence to find, where a permeable rock (such as the Lower Keuper Sandstone) dips down beneath a relatively impervious one (such as the Keuper Marl), that the water standing in the portion of the permeable (and fissured) rock below the impermeable formation has a high saline content.

Although the Lower Keuper Sandstone is locally flexed, it has in this district a prevalent south-easterly dip. The site of the Original Spring, owing to anticlinal flexing and river erosion, is the last place in a south-eastward direction at which water from the Sandstone can outflow.

THE ORIGINAL (OR ABBOTTS'S) WELL.

Site.—No. 4 on plan, p. 122. At corner of Bath and Smith Streets on the premises of Messrs. E. Francis & Sons, Ltd. See p. 124.

		Thickness Ft.	Depth Ft.
[? Passage Beds]	... ...	18	18
[Lower Keuper Sandstone]	Rock [sandstone] from within which at a depth of three feet rose the mineral water ...	3	21

WISE'S (LATER CURTIS'S) WELL.

Site.—No. 9 on plan. Near the Alexandra Fountain under the L.M. & S. Rly. bridge over High Street. See p. 124.

		Thickness Ft.	Depth Ft.
Well (24 ft.) and boring (18 ft.) :—			
[Passage Beds]	[? Marl in which] a rock [sandstone] presented itself, which was nearly ten feet in thickness	24	24
[Lower Keuper Sandstone]	" a bed of marl "	18	42
	" a rock [sandstone] harder than the former " " in which a cleft was found, through which a copious supply of the mineral water is procured "		

ROBBINS'S WELL.

Site.—No. 11 on plan. Victoria Colonnade. See p. 125.

		Thickness Ft.	Depth Ft.
Well :—			
[? Alluvium and " Passage Beds "]	" Blue clay or marl "	12	12
	" Two or three thin strata of sandstone " . . increasing in thickness as they went on [i.e. down] "		
[Lower Keuper Sandstone]	" A solid rock . . . which being struck into poured forth a body of strong saline water, that soon nearly filled the well "	8	20

READ'S WELL.

Site.—No. 5 on plan. London Road Garage adjacent to the Crown Hotel, High Street.

		Thickness Ft.	Depth Ft.
[Drift]	" Gravel, in which is a spring of fresh water "		60
[? Keuper Marl and ' Passage Beds ']	" Marl "	8	
	" White clay and sandstone, in which water of a brackish taste was found "		
[Lower Keuper Sandstone]	" Hard rock probably sandstone "	28	
	" Softer stone ditto "		
	" Marl . . . below which the water rises "		

NEW WELL.

Site.—No. 2 on plan. In the Jephson Gardens opposite the Royal Pump Room and Baths and close to the River Leam.

Sunk in 1902, and particulars communicated by J. J. Kennan, Borough Surveyor.

Height above O.D., 168 ft.

		Thickness Ft.	In.	Depth Ft.	In.
	Soil	4	6	4	6
[Alluvium]	Red clay	5	3	9	9
	Blue clay....	8	0	17	9
[River Gravel]	Gravel	3	6	21	3
[Lower Keuper Sandstone]	Sandstone, soft, brown	12	6	33	9
	Sandstone, fine, white (source of mineral water)	18	6	52	3

Water-level (rest), usually 10 ft. below surface of the ground. The water from the Alluvium and gravel is shut out.

A boring, ' No. 2 ', was made previous to (in 1901) the sinking of the well (in 1902).

Dr. C. Loudon said[1] :—" Bissett's Well, at the north-east corner of Leam bridge, which is of a sulphuric-chalybeate nature without being, like the others, combined with any of the neutral salts. It has not hitherto been employed medicinally."

The description of the site of Bissett's Well corresponds with that of the New Well, but J. J. Kennan has no knowledge of a previous well or spring on this site. Probably there was once a spring from the Leam-side Alluvium and gravel here.

EXPERIMENTAL BORINGS MADE BY THE CORPORATION IN SEARCH OF SALINE SPRINGS IN 1901.

Particulars communicated by the late H. Bright, Chairman of the Water Committee.

No. 1.—Near the old Mill (demolished).

		Thickness Ft.	In.	Depth Ft.	In.
	Soil	1	6	1	6
[River Gravel]	Gravel	1	0	2	6
[Alluvium]	Red clay	1	9	4	3
	Blue clay...	4	3	8	6
[' Passage Beds ']	White rock	2	8	11	2
	Red marl...	3	6	14	8
[Lower Keuper Sandstone]	Dark brown rock [sandstone] ...	1	1	15	9
	Red rock [sandstone] containing fresh water	3	11	19	8
	Fine hard grit [coarse sandstone]	16	10	36	6
	White rock [sandstone] ...	13	6	50	0
	Red rock [sandstone]	20	0	70	0

Result.—No saline water.

[1] ' A Practical Dissertation on the Waters of Leamington Spa . . . ' (3rd ed., 1831), p. 20.

No. 3.—In Royal Pump Room grounds near the entrance to the Swimming Baths.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
	Soil	1	3	1	3
[Alluvium]	Clay	4	3	5	6
	Yellow Rock	1	0	6	6
	Blue clay...	7	10	14	4
[River Gravel]	Gravel	5	0	19	4
[Lower Keuper Sandstone]	White rock	17	2	36	6
	Marl	4	0	40	6
	White rock	11	6	52	0
	Marl	3	0	55	0
	Hard red rock	11	6	66	6

Water-level (rest), 7 ft. 6 in. below ground level.

No. 4.—In the Warneford Hospital grounds.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
	Soil	2	6	2	6
[Drift]	Yellow loam	2	6	5	0
	Dry gravel	9	6	14	6
[Keuper Marl]	Marl	52	2	66	8
[L. Keuper Sandstone]	Fine red grit	4	0	70	8

Water-level (rest), 14 ft. 9 in. below ground level.

Analyses.

Analyses made in February, 1923. Published in ' The Spas of Britain ' (1923), p. 95—the Official Handbook of the British Spa Federation.

	Pump Room No. 1 Strong[1]	Pump Room No. 2 Mild[2]	Aylesford Well.
	Grains per pint.		
Calcium carbonate ...	0·77	1·14	1·16
Calcium sulphate... ...	29·72	8·67	18·47
Magnesium sulphate ...	3·31	—	6·32
Magnesium chloride ...	7·26	4·00	—
Calcium chloride ...	—	2·60	—
Sodium chloride	111·64	18·88	50·90
Sodium sulphate ...	—	—	4·51
Potassium chloride ...	0·26	—	—
Silica	0·02	0·01	—
Iron bicarbonate ...	0·29	0·19	0·05
Total solid grains per pint	153·27	35·49	81·41

[1] From New Well.

[2] From well under Pump Room. L.R.

	Parts per 100,000		
Calcium carbonate ...	8·80	13·00	13·20
Calcium sulphate ...	339·69	99·13	211·06
Magnesium sulphate ...	37·78	—	72·24
Magnesium chloride ...	82·94	45·68	—
Calcium chloride... ...	—	29·74	—
Sodium chloride	1275·83	215·74	581·72
Sodium sulphate ...	—	—	51·53
Potassium chloride ...	2·98	—	—
Silica	0·20	0·10	—
Iron bicarbonate ...	3·34	3·00	0·56
Total solids in parts per 100,000	1751·56	406·39	930·31

The water is radio-active and has a specific gravity of 1·011049. Among Continental Mineral Waters the springs may be compared with those of Homburg, Kissingen and Wiesbaden.

Public Fountain.

Or Alexandra Fountain. See p. 124. Made by John Cutting, of Bath Street. Sept., 1866.

Dr. F. Goodchild—'Mineral Waters of Leamington: their Medicinal Properties and Uses' (1870), p.3, 8vo., Leamington.

Contents of an Imperial Pint.

	Grains.
Specific gravity	1·0108
Sulphate of soda	42·9
Chloride of calcium	33·5
,, ,, magnesium	15·1
,, ,, sodium...	34·7
Silica	·12
Iron	·18

Iodine and Bromine not sought for.

'Hudson's Spring' (Read's Well).

Dr. F. Goodchild—'Mineral Waters of Leamington: their Medicinal Properties and Uses' (1870), p. 3.

Contents of an Imperial Pint.

	Grains.
Sulphate of soda	34·29
Chloride of sodium	55·27
,, ,, calcium...	25·6
,, ,, magnesium	4·5
Silica	8·58
Peroxide of iron	8·58

Dr. Goodchild says:—"This Spring contains the same Saline ingredients [as the Royal Pump Room and Alexandra Fountain waters], and is strongly impregnated with Sulphuretted Hydrogen."

Borough of Stratford-on-Avon

The Borough of Stratford-on-Avon was enlarged on 1st October, 1924, by the inclusion of the parish of Alveston.

The enlarged Borough is mainly on the Keuper Marl, on the surface of which are deposits of sand and gravel belonging to a river-terrace, and, alongside the River Avon, Alluvium. The greater part of the town of Stratford-on-Avon is on gravel and sand resting on the Marl. To the north-west of the town is a tract, about a square mile in extent, on the Lower Lias. In this area is the Royal Victoria or Bishopton Spa, Bishopton, the mineral waters to which it owed its origin in 1837 being found in the Lower Lias. (See p. 142.)

In early days Stratford-on-Avon derived the bulk of its domestic supply from shallow wells sunk in the gravel (see G. T. Clark's Report).[1] In 1886 a storage reservoir was constructed at Snitterfield to conserve water which formerly maintained a feeder of the Ingon Brook. In 1895 this supply was supplemented, by arrangement, with water from a deep boring at Messrs. Flower & Sons' Brewery, Stratford-on-Avon; while at the present time (1925) the existing supply is in the process of being augmented from two deep boreholes, sunk in 1923-24, on the site of the Corporation's Warwick Road Pumping Station.

Corporation Waterworks

Supply Stratford-upon-Avon Borough (1525 out of 1985 houses: see also Alveston Supply, p. 140); and 2 out of 10 houses in Milcote (Stratford-upon-Avon R.D.).

Sources of Supply:—

(1) Gathering ground, gravel and sand on Keuper Marl, 90 acres in extent, at Snitterfield (for analysis see p. 141).

(2) Borehole, Messrs. Flower & Sons, Ltd., Brewery Street, Stratford-upon-Avon. (Water delivered into town mains).

(3) Boreholes, Warwick Road Pumping Station, Stratford-upon-Avon (in process of being added, 1925).

The average daily quantity of water available from each source is, respectively:—(1) 315,000 gallons; (2) 120,000 gallons; (3) see p. 139.

Messrs. Flower & Sons' Brewery Well.

Made (percussion) by Messrs. E. Timmins & Sons, Ltd., completed in 1895. Record by Messrs. E. Timmins & Sons, Ltd., and published by H. T. Brown, *Geol. Mag.*, 1896, pp. 54, 55.

Surface-level, 144 ft. above O.D.

[1] The history of the water-supply of Stratford-on-Avon is given in 'Excursion to Stratford-on-Avon . . .' *Proc. Cotteswold Nat. F.C.*, vol. xxii, pt. 2, for 1925 (1926), pp. 74-76.

		Thickness Ft.	Depth Ft.
Keuper Marl.	1. Red marl	45	45
	2. Red marl and gypsum ...	15	60
	3. Grey marl and gypsum ...	5	65
	4. Red marl and gypsum ...	83	148
	5. Plastic red marl	58	206
	6. Red and grey marl and gypsum	10	216
	7. Red marl and gypsum ...	9	225
	8. Grey marl and gypsum ...	20	245
	9. Red marl and gypsum with a little sand	15	260
	10. Plastic red marl	25	285
	11. Red marlstone with bands of white sandstone ...	29	314
	12. Red marl and gypsum ...	37	351
	13. Red and brown marlstone with a little gypsum ...	31	382
	14. Red marl with a little gypsum	13	395
	15. Brown marlstone ...	31	426
	16. Red plastic marl with a little gypsum	74	500
	17. Mottled red marl with blue veins	25	525
	18. Red and grey marl ...	21	546
	19. Sandy red marl	4	550
	20. Red marl with gypsum ...	24	574
	21. Marlstone	30	604
Lower Keuper Sandstone	22. Brown sandstone	3	607
	23. Grey marl	3	610
	24. Fine light-red sandstone ...	10	620
	25. Grey marl	3	623
	26. Fine light-grey sandstone...	4	627
	27. Grey sandstone	48	675
	28. Light red sandstone ...	5	680
	29. Light reddish-grey sandstone	7	687
	30. Grey sandstone	85	772
	31. Red sandstone	4	776
	32. Grey sandstone	28	804

Brown estimated that the boring commenced at from 25 to 30 ft. below the base of the Rhaetic—in other words that the Keuper Marl has a maximum thickness of 634 ft. in the vicinity of Stratford-on-Avon. He considered that bed 11 was equivalent to what would now be called the Arden Sandstone. Beds 22-32 he termed "Passage Beds". He said:—"The . . . boring unfortunately does not give us the thickness of the Lower Keuper, but as this subdivision of the Trias was penetrated to a depth of exactly 200 ft. and still maintained the same characters, I think it probable that it is at least 300 ft. thick and perhaps more". (See p. 138 of this Memoir.) Brown also observed:—"The whole of the Upper Keuper was perfectly dry, but water was met with directly the Lower Keuper was touched at 604 ft. This increased in quantity as the

boring penetrated further into the sandstones, and a supply of 8,000 gallons an hour is now being pumped, without any signs of exhaustion. The artesian head of the water is considerable and is sufficient to afford a natural flow of 1,800 gallons per hour at a height of 50 feet from the surface."

According to F. W. Jones, Borough Surveyor, (5.11.1924) :— " The head is now reduced but no one appears to know the exact artesian head at the present time."

Analyses.

(H. T. Brown, *Geol. Mag.*, 1896, p. 55.)

	Bore Water, Lower Keuper. (Grains per gallon.)	Well in Upper Keuper.
Sodium chloride	4·50	3·12
Sodium nitrate	0·06	—
Sodium sulphate	6·87	—
Sodium carbonate	2·75	—
Potassium sulphate	0·61	—
Magnesium sulphate	—	6·95
Magnesium carbonate	1·13	16·61
Calcium nitrate	—	2·46
Calcium carbonate	4·41	—
Calcium sulphate	—	122·50
Silica	0·62	Trace
Alumina...	0·08	Trace
	Parts per million	
Ammonia, free and saline	0·10	0·085
Ammonia, albuminoid...	Faint trace	0·045
Oxygen absorbed in three hours ...	0·18	0·029

Analyses of Water from Lower Keuper Sandstone.

1. 16th April, 1923. W. T. Burgess. 2. 1896. H. T. Brown. 3. 1920. W. T. B.

	Parts per 100,000		
	1.	2.	3.
Total solid residue	30·80	30·04	32·22
Ammonia, free	·0075	—	—
Ammonia, albuminoid	·0005	—	—
Nitrogen as nitrates	0	—	0
Nitrogen as nitrites...	0	—	0
Oxygen absorbed in 4 hrs. at 26·7°C.	·005	—	·004
Chlorine (combined)	3·70	3·90	3·95
Lime (CaO)	3·0	3·53	3·90
Magnesia (MgO)	0·55	0·77	0·60
Soda (Na_2O)	11·11	10·12	11·26
Potash (K_2O)	—	0·47	—
Sulphuric anhydride (SO_3)... ...	6·65	5·93	7·43
Carbonic acid (CO_2) (Fixed) ...	5·28	5·24	5·19
Oxides of iron and alumina (Fe_2O_3 and Al_2O_3)	·08	—	·08
Silica (SiO_2)	1·05	0·89	0·98

WARWICK ROAD PUMPING STATION, No. 2 Borehole.[1]

Made in 1923-24, by Messrs. E. Timmins & Sons, Ltd., Runcorn. Record published by L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 283.

Engine-room floor level, 122 ft. above O.D.

Shaft (8 ft. diameter to 20 ft.) and boring (21 in. diameter to 194 ft. 4 in.; 15 in. to 640 ft. 6 in.; 12 in. to 688 ft. 9 in.) :—

	Thickness		Depth	
	Ft.	In.	Ft.	In.
Ground-level below engine-room floor level ...	1	6	1	6
1. Gravel	15	0	16	6
Keuper Marl :				
2. Marls, red, with one or two greenish zones, and rarely greenish blotched, with numerous layers and veins of fibrous gypsum	421	9	438	3
3. Marls, as above, *but devoid of gypsum* ...	33	3	471	6
'Passage Beds' :				
4. Marl, greenish	2	6	474	0
5. Sandstone, whitish-green, "cellular" ...	1	0	475	0
6. Marl, greenish	1	9	476	9
7. Marl, deep red	3	10	480	7
8. Marl, greenish	2	2	482	9
Lower Keuper Sandstone :				
9. Sandstone and marl partings, greenish	2	3	485	0
10. Sandstone, greenish, fissile *richly micaceous*	5	3	490	3
11. Marl, greenish		9	491	0
12. Sandstone, greenish-grey	29	6	520	6
13. Marl, greenish		6	521	0
14. Sandstone, grey	4	6	525	6
15. Marl, red	1	0	526	6
16. Marl, darker red and locally greenish ...		9	527	3
17. Sandstone, grey	7	0	534	3
18. Marl, red, locally greenish	1	2	535	5
19. Marl, dark purplish		1	535	6
20. Sandstone, grey	1	4	536	10
21. Marl, red, and locally greenish ...		11	537	9
22. Sandstone, grey	6	3	544	0
23. Marl, grey		4	544	4
24. Sandstone, grey		6	544	10
25. Marl, grey		3	545	1
26. Sandstone, grey, very coarse-grained ...	6	8	551	9
27. Sandstone, red, with patches of grey ...	2	0	553	9
28. Marl, red		3	554	0
29. Sandstone, grey	1	0	555	0
30. Sandstone, dark grey	1	6	556	6
31. Sandstone, grey	15	3	571	9
32. "Grey Conglomerate"—irregular hard calcareous portions of sandstone in a mainly decalcified sandstone	2	6	574	3
33. Sandstone, grey, coarse-grained ...	2	6	576	9
34. "Grey Conglomerate"—as above ...	4	3	581	0
35. Sandstone, grey	8	6	589	6

[1] No. 1 Borehole was abandoned for a time but was subsequently proceeded with.

	Thickness		Depth	
	Ft.	In.	Ft.	In.
36. " Grey Conglomerate "—as above ...	3	3	592	9
37. Sandstone, grey, coarse-grained, with patches of " Grey Conglomerate " and bits of greenish marl	3	9	596	6
38. Marl, red and greenish	1	0	597	6
39. Sandstone, red	1	0	598	6
40. Sandstone, grey		9	599	3
41. " Marl Conglomerate "—sandstone with " nodules " and bits of marl ...	2	3	601	6
42. Sandstone, red and grey, with locally " marl conglomerate "	1	9	603	3
43. Sandstone, grey, with locally " marl conglomerate "	5	6	608	9
44. Sandstone, grey	5	0	613	9
45. Sandstone, grey, coarse-grained ...	2	6	616	3
46. Marl, purple		3	616	6
47. Sandstone, red, with a few small pebbles	1	0	617	6
48. Sandstone, red, with splashes of grey, and hard grey marl-" nodules " and a few small pebbles		9	618	3
49. Sandstones, red and grey, with locally " marl conglomerate "...	3	0	621	3
50. Sandstone, very soft, grey, with bits of greenish marl	1	9	623	0
51. Sandstone, grey, with locally " marl conglomerate "	1	3	624	3
52. Sandstone, soft, grey. (Only 1 ft. of core drawn.)	2	6	626	9
53. Pebbly sandstone	3	0	629	9
54. Sandstone, grey, with bits of greenish marl	1	0	630	9
55. Sandstone, red and grey, with a few small pebbles	1	3	632	0
56. Sandstone, grey, with bits of greenish and red marl and small pebbles (Core wasted)	2	6	634	6
57. Pebbly sandstone. Vein-quartz pebbles, etc., occasional subangular pebbles of quartzite (resembling Lickey Quartzite) in coarse-grained, grey sandstone resting on a layer of non-pebbly, grey sandstone ... ... which is joined on to	1	0	635	6
Unconformity				
? Upper Coal Measures (*olim* Permian). Probably Enville Group :—				
58. Marl, chocolate-coloured, slickensided, the upper part including a 3-inch band of sandy breccia with greenish subangular rock-fragments, occasional pebbles of vein-quartz and subangular pieces of quartzite, resembling Lickey Quartzite, up to 3 in. in diameter ...	1	0	636	6

	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
59. Sandstone, dark reddish or purplish, with occasional thin layers of chocolate-coloured marl and thin bands of grit and breccia (similar to the finer varieties of Enville Breccia). At about 20 ft. below the unconformity was a 6-inch band of fine breccia	52	3	688	9

The cores of beds 58 and 59 broke obliquely at angles of 30 to 35 degrees owing to the dip of the strata, whereas the beds above the uncomformity dip only slightly, if at all.

Lined with cylinders 7 ft. 4½ in. by 8 ft. to 20 ft. 1 in.
22 in. bore C.I. standpipes to 20 ft. 1 in.
15½ in. by 16¼ in. s/s lining tubes to 194 ft. 4 in: top 1 ft. 10 in. below engine room floor.
12½ in. by 13¼ in. lining tubes to 640 ft. top 190 ft. below engine room floor.

Perforated from 494 ft. to 640 ft.

Yield.—Test (incomplete): 9,500 gallons per hour at 84 ft. depression. Water-level.—Dropped to 84 ft. below engine-room floor level and recovered and overflowed 9 minutes after a 24-hour test and 15 minutes after a 14-days' test.

After the gravel-bed and top portion of the Keuper Marl had been penetrated practically no water was encountered until the Lower Keuper Sandstone was reached; but when the borehole was 491 ft. deep the water rose and overflowed at the surface at the rate of 5,892 gallons per day. There was no increase on reaching the Palaeozoic rocks or on going into them.

Analysis.

From Lower Keuper Sandstone, Borehole No. 2, Warwick Road. 6th Sept., 1924.

Communicated by F. W. Jones, Borough Surveyor.

	Parts per 100,000
Total solid residue	31·20
Ammonia, free	·0095
Ammonia, albuminoid	·0005
Nitrogen as nitrates and nitrites	0
Oxygen absorbed in 4 hrs. at 26·7°C.	·003
Chlorine (combined)	3·40
Lime (CaO)	3·70
Magnesia (MgO)	0·90
Alkalies, calculated as soda (Na_2O)	10·77
Sulphuric anhydride (SO_3)	7·11
Carbonic acid, fixed (CO_2)	5·56
Oxides of iron and alumina (Fe_2O_3 & Al_2O_3) ...	·10
Silica (SiO_2)	1·22
Total hardness, calculated from Lime and Magnesia	8·9

Remarks.—The water is clear and of high organic purity, and is of almost the same composition as that derived from the Brewery well (see p. 136).

ALVESTON HILL WORKS.

The parish of Alveston was taken into the Borough of Stratford-upon-Avon 1st October, 1924.

The Works supply that portion of the Borough of Stratford-upon-Avon which was formerly the parish of Alveston.

Source of Supply :—Borehole at Alveston Hill. The average daily quantity of water available is :—About 72,000 gallons (F. W. Jones).

Quality of water[1] :—Satisfactory. Hardness : 10°. Acts on lead, but iron pipes are used.

Boring completed April, 1898. Dr. C. A. Matley, *Quart. Journ. Geol. Soc.*, vol. lxviii (1912), pp. 271-273. See also L. Richardson & W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 287.

Height above O.D., 187 ft.

		Thickness Ft.	Depth Ft.
Soil and Gravel	1. Soil	1	1
	2. Small gravel	11	12
Keuper Marl	3. Red marl with small pebbles	128	140
	4. Red gypseous marl	95	235
	5. Grey gypseous marlstone ...	5	240
	6. Sandy marl	1	241
	7. Red marl	174	415
	8. Grey marl	31	446
	9. Red marl	54	500
	10. Red sandy marl	17	517
	11. Red marl and grey bands ...	17	534
	12. Red marl	13	547
	13. Greenish-grey marl	1	548
	14. Red and grey marl	1	549
[Lower Keuper Sandstone]	15. Coarse grey sandstone ...	30½	579½
	16. Red marl	1½	581
	17. Grey sandstone with thin seams of grey marl ...	14	595
	18. Red marl	2½	597½
	19. Dark grey sandstone	22½	620
	20. Coarse grey sandstone ...	15	635
	21. Grey marl	1	636
	22. Pale-grey sandstone	12	648
	23. Dark-grey sandstone ...	28	676
	24. Very fine grey sandstone ...	22	698
[? Enville Group]	25. Fine red sandstone ...	6	704
	26. Fine grey sandstone	3	707
	27. Fine red sandstone	21	728
	28. Dark purple marl	26	754

Lined with 11-inch tube (10-inch internal diameter) to 200 ft.
8¾ ,, ,, (8- ,, ,, ,,) to 592½ ft.
then a 7⅛-inch borehole.

[1] Return as to Water Undertakings in England and Wales, 1915, p. 136. *Local Government Board.*

Yield.—Dr. Matley says (p. 272) :—" There was a yield of over 60,000 gallons of water per day. At first a little trouble arose from oxidation of iron in the pipes, but that trouble soon ceased."

According to F. W. Jones, Borough Surveyor, the yield is " About 3,000 gallons per hour with a depression of 60 feet during pumping."

The numbers for the beds have been added. Dr. Matley summarized the section as follows :—

		Thickness in Feet
[1, 2.]	Soil and gravel	12
[3-14.]	Keuper Marl (with probably a few feet of marly drift)	537
[15-28.]	Lower Keuper Sandstone	205
	Total	754

but observed (p. 273) :—" The thickness [26 ft.] of the marl forming the lowest bed reached . . . suggests the possibility that the Lower Keuper Sandstone was completely passed through, and the marls and sandstones of the ' Permian ' of the Warwickshire district reached."

It is most probable that the marl is ' Permian ' : and it appears likely that the three sandstones above (of his record), totalling 30ft., belong to the same Palaeozoic formation and are comparable with the ? Enville Sandstone of the Warwick Road Boring.

Analyses.

Water from Lower Keuper and ? Enville Sandstones, Alveston Hill Boring. Analysis made by Messrs. Bostock Hill and Rigby, Birmingham. 28.10.15.

	Parts per 100,000
Free and saline ammonia	0
Organic ammonia	0·005
Chlorine in chlorides	3·9
Nitrogen in nitrates and nitrites	0
Oxygen absorbed in 4 hours at 80°F.	0·031
Total solid matter	33

Analyses of water from gathering-ground [Keuper Marl with locally drift upon the surface, at Snitterfield] before and after passing through Bell's mechanical filters. Communicated by F. W. Jones, Borough Surveyor.

	Parts per 100,000	
	Sand-filtered water.	Bell-filtered water.
Total solid residue	25·48	25·10
Organic carbon	·556	·453
Organic nitrogen	·064	·045
Ammonia, free	·001	·001
Ammonia, albuminoid	·022	·019
Oxygen absorbed in 4 hrs. at 26·7°C.	·365	·311
Nitrogen as nitrates	·070	·076
Nitrogen as nitrites	0	0
Total combined nitrogen	·135	·122
Chlorine (combined)	1·10	1·10
Total lime (CaO)	7·94	7·90
Total magnesia (MgO)	2·0	2·0
Sulphuric anyhdride (SO_3)	3·06	3·89
Total carbonates, calculated as carbonate of lime	14·5	13·7
Total hardness, calculated from lime and magnesia	19·2	19·1

Royal Victoria Spa, Bishopton

The waters of this Spa—as at Cheltenham—were drawn from wells in the Lower Lias.

The earliest evidence of the scientific recognition of a mineral water here appears to be Dr. Charles Perry's ' An Account of an Analysis made on the Stratford Mineral Water comprehending near Thirty Different Experiments, with Observations Thereon, and Conclusions drawn from the Whole,' published in 1744[1].

According to Dr. Perry, the waters ' rose ' in a field called ' Shottery ', and their discovery was due to local people noticing that pigeons frequently resorted to the spot to drink of them. He recorded that several invalids had taken the waters to their benefit ; more about 1742-43 ; while quite a number from the neighbouring towns and villages had made use of them in 1744.

In 1745 William Baylies, Jun., wrote ' Short Remarks on Dr. Perry's Analysis made of the Stratford Mineral Water : with a Short Essay by way of Appendix towards a more Perfect Examination of the Same Water.'[2]

The Royal Victoria Spa was opened on 24 May, 1837, and the building extended later.[3] When Dr. A. B. Granville visited the Spa[4] he was much impressed with the efforts—chiefly of a Mr. Hunt—that had been made to make it a first-class Spa. There was a Pump Room, " in the rustic Gothic style ", a range of baths

[1] 8vo. Northampton. Reprint, 1870, pp. 48. Hanley : Allbut and Daniel, Printers, Market Square.

[2] 8vo. Stratford-on-Avon.

[3] F. C. Wellstood, Secretary and Librarian at Shakespeare's Birthplace, Stratford-on-Avon, informs me that in the library at the Birthplace is a small volume of drawings showing the various buildings which were first erected when the Spa was established.

[4] ' The Spas of England : Midland Spas ' (1841), p. 274.

(three for men and three for women) adjoining, and, in the same grounds, Green's Hotel, which was sumptuously and comfortably equipped.

The ' original well ' was 47 feet deep, had 20 feet of water in it when Granville was there, and was situated in the flower garden in front of (east of) the Pump Room. A second ' spring ' was later discovered by sinking another well, but Granville pointed out that it came from the same source as the ' original well,' because when water was drawn from that well the water-level was lowered in the new well.

By 1858 the Spa was apparently in financial difficulties, for the piece of ground adjoining the Spa on the western side was mortgaged for £1,000 and in 1868 the hotel failed. A company was formed for the purpose of conveying the water to a central hall in Stratford-on-Avon, but the scheme fell through.

Now (1925) the Pump Room and Baths are rapidly decaying, and Green's Hotel is tenantless.

About 1912-13 a proposal was made to build a large hydropathic establishment in Stratford-on-Avon, but this plan was also abortive. The Spa water was analysed at the time (see below) ; the analysis shows that it contains less mineral matter than the water from the same formation at Hampton Spa, near Evesham, and less sulphur trioxide. This sulphur trioxide is probably present as sulphate of soda, which would be quite good for the liver.

Analysis.

By Prof. P. F. Frankland. Date 1912 or 1913.

	Parts per 100,000	Grains per gallon
Silica	0·82	0·57
Oxide of iron and alumina (Fe_2O_3 and Al_2O_3) . .	0·18	0·13
Chlorine (Cl)	56·00	39·20
Nitric acid (N_2O_5)	0·24	0·17
Sulphuric acid (SO_3)	166·48	116·54
Alkalies calculated as soda (Na_2O)	178·86	125·20
Magnesia (MgO)	10·90	7·63
Lime (CaO)	11·74	8·22
Ammonia (free and saline)	0·11	0·077
Organic carbon	0·271	0·190
,, nitrogen	0·086	0·060

Borough of Sutton Coldfield

The distribution at the surface of the geological formations within the Borough is shown on the one-inch Geological Survey Maps, New Series, Sheets 154, 168. It is therefore unnecessary to go into detail here. Attention may, however, be directed to the following matters : a fault, running approximately north and south, occurs to the east of the town, by which Keuper

Marl is let down on the east side against Lower Keuper Sandstone on the west. From Little Sutton the fault is directed north-eastwards. Within the Borough the oldest rock visible at the surface belongs to the Enville (Corley or Hamstead) Group. This Group was pierced to a depth of 1,830 ft. at Little Aston (Streetly), just outside the Borough boundary, without the base being reached. The constituent beds are mostly marls and therefore water-upholding : they uphold the water in Bracebridge Pool. Hopwas Breccia is mapped as flooring the greater part of the Hill district. The Hopwas Breccia is followed by Bunter Pebble Beds, which floor ' the peak ' of the Borough in the vicinity of Camp Farm and Sutton Park. South of Camp Farm a fault with a west-north-west and east-south-east trend traverses the Borough and lets down permeable Hopwas Breccia and overlying permeable Bunter Pebble Beds against impermeable Enville (or Corley) Beds capped with Hopwas Breccia on the south. The Enville (or Corley) Beds will function as a subterranean dam, and in an area situate about half a mile north-east of Camp Farm the South Staffordshire Waterworks Company have obtained powers to sink a well. Locally, Glacial sands, gravels and boulder clay overlie and obscure the surfaces of the solid formations ; whilst in valleys and down by brooks occur locally river-gravels and alluvium.

Springs occur all over the Borough and especially in the Park in which the surface of the impermeable Enville (or Corley) Beds is locally not deeply buried beneath younger deposits. The Triassic sandstones and pebble beds are very permeable and considerable pumping or the construction of deep sewer trenches soon lower the rest levels in wells over considerable areas.

Out of 5,957 houses in the Borough, 5,713 are supplied from the South Staffordshire Waterworks Company's mains which are filled from the reservoirs at Barr Beacon and Shenstone. The houses not so served are dependent on wells—up to about 50 ft. in depth—the supplies from which are adequate. Water from the Hopwas Breccia cut through by the railway-cutting north of Four Oaks Station is piped to a catch-tank at the Station from which it gravitates through pipes to the Locomotive Sheds at Sutton Coldfield Station.

There are no large works in the Borough and apparently the Clarence Road Boring is the only one that has been made.

CLARENCE ROAD BORING.

About 330 yards south of Blake Street Station on a site where Messrs. Holt proposed to establish a Creamery and Cheese Making Works, but gave up the project. Made in 1919 and communicated by Messrs. C. Isler & Co., Ltd.

Height above O.D., about 410 ft.

		Thickness Ft.	In.	Depth Ft.	In.
[River Gravel]	Ballast	15	0	15	0
[? Hopwas Breccia]	Conglomerate	60	0	75	0
[? Enville Group]	Marl		6	75	6
	Soft sandstone	2	6	78	0
	Sandstone	20	6	98	6
	Conglomerate	7	6	106	0
	Hard sandstone with pebbles ...	16	0	122	0
	Conglomerate with bits of marl	4	6	126	6
	Hard sandstone with pebbles ...	20	6	147	0
	Hard sandstone...	41	0	188	0
	Sandstone with pebbles ...	4	9	192	9
	Conglomerate	48	7	241	4
	Marl...	7	3	248	7
	Greenish marl stone	7	5	256	0

Lined with 36 ft. of tubes 8 in. in diameter, top 6 ft. 6 in. down.
76 ft. ,, 6 in. ,, ,, 1 ft. 9 in. ,,

Water-level, 36 ft. ex surface.

The cores—so far as is known—were not seen by a geologist. The 60 ft. of conglomerate may be Hopwas Breccia : on the other hand there may not be any of this rock present.

Analyses.

Water supplied by the South Staffordshire Waterworks Company.

1. from tap, Hill Ward ; 2. from tap, Walmley Ward.

Analyses made by Messrs. Bostock Hill & Rigby, Birmingham. 3.9.24. Communicated by W. A. H. Clarry, Borough Surveyor and Engineer.

	Parts per 100,000 1.	2.
Free and saline ammonia	0·000	0·000
Albuminoid ammonia	0·002	0·003
Chlorine in chlorides	2·450	2·400
Nitrogen in nitrates and nitrites	0·550	0·550
Oxygen absorbed from permanganate at 80°F. in 4 hours	0·019	0·019
Total solids dried at 100°C.	31	30·5
Hardness : Temporary	4·0	3·7
Permanent	13·7	14·3
Total	17·7	18·0

Appearance.—1 and 2, bright, few small particles.

Borough of Warwick

The town of Warwick is situate about the centre of the two large parishes of St. Mary and St. Nicholas. This area is traversed by a fault, the southern portion of the Western Boundary Fault of the Warwickshire Coalfield, which has an approximately north and south alignment. To the west of this fault is the Keuper Marl ; to the east, Lower Keuper Sandstone. This latter formation rests on an

apparently undulating surface of Enville Beds (*olim* ' Permian '). Owing to the local removal of the superincumbent sandstone, Enville Beds are displayed at the surface in a small tract between The Cape and The Union Workhouse, and extend from about the line of the canal southwards to the Priory Pools. In this area they consist of red and grey marls with thin beds of sandstone : the clayey marls were formerly dug for brickmaking immediately east of the fault at The Cape.

Howell, in the Memoir of 1859[1], says that a boring was made in these Permian—that is, Enville—beds to the depth of 700 ft. ; that the beds consisted mostly of marl with thin beds of sandstone ; and that only a little water was tapped and that was ' salty '. Similar strata penetrated to a depth of 334 ft. at Emscote Mills yielded satisfactory water to the amount of 300,000 gallons per day, but it is to be noted that the boring first pierced 72 ft. of Lower Keuper Sandstone.

It may be an Enville Group sandstone from which the Corporation's Woodloes Well derives its water, and a higher sandstone-mass in the same Group in which Messrs. Austin Edward's borehole is sunk.

The Lower Keuper Sandstone succeeds the Enville Group unconformably. It (? and Enville Group sandstone) is pierced by the Warwick Laundry boring, and deep wells in it provided in the past the bulk of the supply for the town.

River-terrace gravels occur at and in the vicinity of St. Nicholas Meadow, and gravel also occurs locally on the surface of the Triassic beds.

Corporation Waterworks

Works established 1874. Supply Warwick Borough (2,970 out of 3,000 houses) ; and furnish a supply in bulk to Sir F. Waller, Bart., who supplies part of the parish of Leek Wootton (Warwick R.D.).

Source of Supply :—

(1) ' Adits ' (extended in 1889 and 1897)—collecting pipes laid mostly in gravel resting on Keuper Marl, but partly in the Marl, Haseley.

(2) Well (lined with cast iron cylinders down into the rock) at Woodloes (see p. 147).[2]

The average daily quantity of water derived from each source is, respectively :—

(1) 280,000 gallons and a further 70,000 gallons per day could be obtained.

[1] ' The Geology of the Warwickshire Coal-Field,' *Mem. Geol. Surv.*, 1859, p. 31.

[2] Water from Haseley gravitates to the Hatton service reservoir : that from Woodloes is pumped either into the town mains or to the service reservoir.

(2) 80,000 gallons and a further 70,000 gallons per day could be obtained.

Woodloes Trial Boring. Communicated by W. Whitaker, F.R.S.

	Thickness Ft.	Depth Ft.
Gravel	14	14
Lower Keuper Sandstone	2	16

Result.—Plenty of water.

Woodloes Well. Communicated by R. Wormell, Borough Engineer and Surveyor. Height above O.D., 180 ft. Diameter of well 10ft.

	Thickness Ft.	Depth Ft.
[Soil and ? Alluvium] Soil	2	2
[? Lower Keuper Sandstone] Sandstone	20	22

Rest-level, 2 ft. below the surface. Yield, 150,000 gallons per day.

The trial boring was made close to where the well was sunk and the difference in the rocks said to have been pierced by the well is noteworthy. The classification of the sandstone of the well-section as Lower Keuper Sandstone is queried as it may be an Enville Group sandstone.

Analyses.

Communicated by R. Wormell, Borough Engineer and Surveyor. 19.11.1924.

1. Haseley Supply.
2. Town water—Haseley and Woodloes Supplies mixed.

	In parts per 100,000	
	1.	2.
Free and saline ammonia	0·008	0
Albuminoid ammonia	0·008	0·010
Chlorine in chlorides	2·300	2·0
Nitrogen in nitrates and nitrites	0·550	0·38
Oxygen absorbed from permanganate at 80°F. in 4 hours	0·091	·126
Total solids dried at 100°C.	40·000	35·000
Hardness: Temporary	8·42	10·1
Permanent	14·58	16·9
Total	33·00	27·0

Appearance.— 1. Bright, many small particles.
2. Bright, containing a few small particles.

Town Boring.

H. H. Howell said :—" Above this [Enville] conglomerate the Permian [now Enville Group, ? Upper Coal Measures] beds become more marly, with fewer beds of calcareous breccia and conglomerate. These are well exposed between Coventry, Kenilworth and Warwick, in the Leamington and Coventry Railway, and their marly character

was further proved near Warwick, where a boring was made, to supply the town with water, through 700 feet of rock, consisting mostly of marl and thin beds of sandstone ".[1]

Enquiries made locally have been unsuccessful in obtaining further particulars of this boring or its site. Probably it is that noticed by E. Pritchard as " 400 feet deep near the Union Workhouse "—a quarter of a mile north of the Great Western Railway Station.

EMSCOTE MILLS BORING.

Messrs. George Nelson, Dale & Co., Ltd., by canal side not quite half a mile east-north-east of the Great Western Railway Station, Warwick. Made in 1920 and particulars communicated by Messrs. E. Timmins & Sons, Ltd. Height above O.D., 174 ft.

Borehole (diameter, 8 in.):—

		Thickness Ft.	Depth Ft.
	Drift	14	14
[Lower Keuper Sandstone]	Grey sandstone with marl beds	72	86
[? Enville Group]	Purple marls and thin red and grey sandstones	334	420

Rest-level, 14 ft. below the surface. Yield, 300,000 gallons per day. Quality of water.—Satisfactory—' not salty '.

WARWICK LAUNDRY.

In St. Nicholas Meadow, a third of a mile east-south-east of the Great Western Railway Station, Warwick. Made in 1906 by Messrs. E. Timmins & Sons, Ltd. Height above O.D., about 162 ft.

Borehole (diameter, 6 in.).—

[Probably through a few feet of river-terrace gravel] ...		100 ft.
[? Lower Keuper Sandstone and ? Enville Beds.]	Red sandstone ...	

Rest-level, 14 ft. below the surface. Yield, about 800 gallons per hour.

ANALYSIS.

Water from Warwick Laundry borehole in Lower Keuper Sandstone and ? Enville Beds. Analysis communicated by the Manager.

Parts per 100,000.

Estimations.		Probable Combinations.	
Lime	8·68	Calcium carbonate ...	15·50
Magnesia	4·82	Magnesium carbonate ...	5·46
Iron	trace	,, sulphide ...	6·66
,, (filtered water)	trace	Sodium sulphate ...	6·31
Chlorine	1·77	Sodium chloride ...	2·93
Sulphuric anhydride ...	8·00		
Carbonic acid	2·20		

Hardness: temporary ... ... 22°
permanent ... ... 5·53°
total ... ... 27·53°

[1] ' The Geology of the Warwickshire Coal-Field,' *Mem. Geol. Surv.*, 1859, p. 31.

MESSRS. AUSTIN EDWARDS, LTD. BORING.

Close to the Great Western Railway Station. Made and particulars communicated by Messrs. G. Lines & Son, Beech Lane, Solihull, Warwickshire. Height above O.D. about 170 ft.

Borehole (diameter, 8 in.).—

[? Enville Group] Sandstone strata throughout ... ... 98 ft.

At the time the boring was completed the water flowed over the top of the borehole.

HEATHCOTE BORING.

A mile and three quarters east-south-eastward of Warwick Castle. Made in 1898-99 by Messrs. E. Timmins & Sons, Ltd. Particulars communicated by H. G. Godfrey-Payton, Agent to the Warwick Castle Estate and published by L. Richardson and W. F. Fleet, *Proc. Geol. Assoc.*, vol. xxxvii, 1926, p. 301. Height above O.D., about 220 ft.

		Thickness Ft.	Depth Ft.
[Keuper Marl]	1. Marls	240	240
[Lower Keuper Sandstone]	2. Red sandstone	7	247
	3. Grey sandstone	61	308
	4. Clay or red shale	1	309
	5. Grey rock [? sandstone] ...	23	332
[? Enville Group]	6. Red marl	19	351
	7. Dull red sandstone... ...	35	386
	8. Redder sandstone	11	397
	9. Red buff marl	2	399
	10. Dull red sandstone... ...	7	406
	11. Red marl	6	412
	12. Dull red sandstone... ...	30	442

Result.—Good water.

The description in the driller's log for the bed numbered 5, ' Grey rock ', suggests ' grey sandstone ', and that it is likely to be Lower Keuper Sandstone. Bed 4 may correspond to bed 38 of the Warwick Road Boring, Stratford-on-Avon, or to a higher marl bed (cf. bed 21).

The character and thickness of bed 6 suggest the commencement of the Enville Group, and the colour assigned to the subjacent sandstones agrees with that of sandstones belonging to the same formation.

V.—WATER SUPPLIES OF COUNTY BOROUGHS

County Borough of Birmingham

The geology of Birmingham is shown on the recently issued one-inch Geological Survey map, New Series, Sheet 168, and six-inch maps are also available. Two editions of the one-inch map are published—a 'Drift' Edition and 'Solid' Edition. The former shows the distribution of the Superficial Deposits, which rest on the 'solid' rocks; the latter that of the 'solid' rocks without their local covering of 'Drift'. For studying shallow-seated sources of water-supply—which should be seldom necessary in view of the fact that Corporation water is everywhere available—the 'Drift' Edition is the better; for studying deep-seated sources—as when boreholes to supply Works are contemplated—the 'Solid' Edition is preferable.

As the geology of Birmingham is shown in detail on the above-mentioned maps it is unnecessary to enter into particulars here; but it is desirable to emphasize certain points.

An important fault, known as the 'Birmingham Fault,' traverses Birmingham in a north-east and south-west direction. By it, the beds on the east side are let down against those on the west. Those on the west side from the surface and for many feet down are highly permeable beds—Lower Keuper Sandstone, Upper Mottled Sandstone, and Pebble Beds: those on the east side from the surface down to a maximum depth of about 600 ft. are impermeable beds (Keuper Marl) overlying permeable beds—Lower Keuper Sandstone, etc. The throw of the fault is at Saltley about 100 ft., at Priory Road, Edgbaston, about 400 ft., at Selly Oak ?about 600 ft., at the Manor House, Northfield, about 280 ft., and at Allens End about 100 ft. Accordingly, borings made east of the fault have to penetrate the impermeable marls before reaching the permeable sandstones and pebble beds.

A geological section, taken across a part of Birmingham, is given on the one-inch Geological Survey map and is reproduced in Fig. 2 on p. 4. It represents the mutual relations of the formations along that line and the effect upon them of the Birmingham Fault. It also shows that, along that line of section, (1) the Pebble Beds attenuate towards the fault and die out to the eastward; (2) the Upper Mottled Sandstone dies out just before the fault is reached; and (3) that the Lower Keuper Sandstone is well developed and persistent to the east of the fault beneath a thick covering of Keuper Marl. If sections were drawn along other east and west lines to the north and south of that taken, differences in detail would manifest themselves: it would generally be found that the covering of Keuper Marl was thicker.

A study of the summary of particulars[1] of the principal boreholes made to the east of the fault (see pp. 163-174) will show the thickness of the impermeable covering, the rest-levels of the water, and the yields of the borehole. So if it were desired to put down a borehole the best information available concerning the probable depth to which it would have to be carried, rest-level, and yield, would be obtained by studying those particulars for the nearest borehole on, of course, the same side of the fault.

Between the undoubted Trias and indubitable Enville Beds (Upper Coal Measures), breccias—of somewhat uncertain age—have been encountered in a number of borings. Prof. W. S. Boulton has stated[2] :—" It is clear that, underlying Birmingham, perhaps the greater part, there exists below the Pebble Beds [Trias] a coarse breccia of thickness unknown, except at Nechells, where it has been proved to be 350 feet thick." Deep borings for water in Birmingham usually stop when the breccia is reached : it is doubtful whether any appreciable addition to their yield would result by continuing boring into it, so when it is detected in a core it will probably be advisable to discontinue boring operations. The breccia has distinctive characters : the contained fragments, which include quartzite resembling Lickey Quartzite, are mostly angular to subangular and therefore unlike the well-smoothed pebbles of the Bunter Pebble Beds.

Deep down, permeable Triassic beds west of the Birmingham Fault are in juxtaposition with permeable Triassic beds, beneath the covering of Keuper Marl, east of the fault. The uncovered beds are traversed by the River Tame, Hockley Brook, Chad Brook, and Bourn Brook. No doubt they supply water to the rocks over which they flow, but locally their water-supplying function has been restricted by the erection of retaining walls and the construction of culverts. The direct percolation of rain in a densely built-over area is greatly diminished by the rain that falls on roofs and roads being carried off by drains. Abstraction by pumping from wells and boreholes, interference with the recharging of the strata by local artificial direction of the brooks, and the diversion of part of the direct rainfall, are causing the water-level to fall locally ; Prof. Boulton has observed[3] :—" In the city of Birmingham and its confines the underground water level is slowly but continuously sinking in some places, indicating that the rocks are being overpumped."

Birmingham Corporation Waterworks[4]

Established as a Waterworks Company by virtue of Act of 1826. Waterworks purchased by the Corporation on 1st January, 1876.

[1] In ' Geology of Birmingham ' (*Mem. Geol. Surv.*), 1925, pp. 126-137.
[2] *Quart. Journ. Geol. Soc.*, vol. lxxx, 1924, p. 353.
[3] *The Engineer*, 1920, p. 647.
[4] Particulars taken mostly from ' Return as to Water Undertakings in England and Wales,' 1915, p. 18. *Local Gov. Bd.*

Supplies Birmingham C.B. ; Perry Barr U.D. (part) ; and parts of the parishes of Alvechurch, Frankley (Bromgrove R.D.) ; Illey (Halesowen R.D.) ; Bickenhall, Castle Bromwich, Coleshill, Curdworth, Minworth, Sheldon, Water Orton (Meriden R.D.) ; Llanwrthwl (Rhayader R.D.) ; Solihull (Solihull R.D.) ; and furnishes supplies in bulk to Coventry T.C.[1] and Meriden R.D.C.

Sources of Supply.—Rivers Elan and Clearwen with gathering ground of 45,562 acres. The average daily quantity of water available from this source is 72,000,000 gallons. The following sources are kept as standbys :—

Source.	Yield capacity per day (gallons)
River Bourne (drainage area : 17 sq. miles) ...	3,750,000
Plant's Brook (,, ,, : 12 sq. miles) ...	2,500,000
Witton or Short Heath Well	2,000,000
Aston Well	2,000,000
Longbridge Well	445,000
River Blythe (drainage area : 73 sq. miles)	

The River Blythe as a source of supply was abandoned about 1905 on completion of the Welsh Scheme, but about 1920, owing to heavy increase in water consumption, it was necessary to revert to its use and up-to-date filtration and sterilisation plant were installed at Whitacre, full particulars of which were given in *The Engineer* for 1920, pp. 622-24, 626.

Analyses.

Welsh Water. Analysis made by J. F. Liverseege, F.I.C., City Analyst.

Published in *Annual Report of the City Analyst*, 1924, p. 9.

[1] To a maximum quantity of 3,000,000 gallons per day, which is pumped from Whitacre into the Coundon reservoir.

Average Composition of Welsh Water.

	AVERAGE RESULTS.	1924	1923	1922	1921	1916–20	1911–15
Parts per 100,000	Total solid matter	4·8	4·7	5·3	5·2	5·7	5·8
	Free ammonia	0·000	0·001	0·000	0·000	0·000	0·000
	Albuminoid or organic ammonia ...	0·004	0·003	0·003	0·006	0·004	0·004
	Nitrogen in nitrates	0	0	0	0	0	0
	Oxygen consumed in 3 hours at 27°C. (80°F.)	0·17	0·15	0·13	0·18	0·16	0·15
	Chlorine in chlorides	0·8	0·8	0·8	0·8	0·9	0·8
	Hardness (as $CaCO_3$)	1·7	1·8	2·8	2·8	3·0	3·1
	Alkalinity (as $CaCO_3$)	1·0	1·1	1·8	1·8	1·9	2·4
Appearance in 2ft. tube.	Turbidity*	0	0	0	0	0	0
	Red†	0·5	0·3	0·3	0·5	0·5	0·4
	Yellow†	3·0	2·2	1·9	2·9	2·8	3·0
	Blue†	0	0	0	0	0·2	0·2

* "0" indicates "clear."

† The colour is expressed in tintometer units. Red with an equal amount of yellow forms *orange*, yellow with an equal amount of blue forms *green*, and equal amounts of the three colours indicate *grey*.

WITTON OR SHORT HEATH WELL.

Communicated by W. Gray, for some time Engineer to the Birmingham Corporation Waterworks. Details (down to 150 ft.) obtained from a tracing of a graphic section in the possession of the Waterworks Department. Height above O.D. 356 ft.

Well (130 ft. deep, 10 ft. in diameter) and borehole (270 ft., 20 ins. in diameter) :—

		Thickness		Depth	
		Ft.	In.	Ft.	In.
[Glacial Sands and Gravels and Bunter]	(Uncoloured)	30	3	30	3
	Sand and gravel	6	0	36	3
	Gravel and clay	4	0	40	3
	Running sand	55	5	95	8
	Loamy sand	15	4	111	0
	Sand and gravel...	23	0	134	0
	Loamy sand		6	134	6
	Marl parting		6	135	0
	Red sandstone	7	5	142	5
	Marl parting	1	0	143	5
	Red sandstone	4	10	148	3
	Marl parting	1	0	149	3
	Red sandstone	8	9	158	0

Water-level.—Overflows. Yield, 2,000,000 gallons per day.

ASTON WELL.

Communicated by W. Gray, for some time Engineer to the Birmingham Corporation Waterworks. Details obtained from a tracing of a graphic section in the possession of the Waterworks Department. See also *Rep. Brit. Assoc.* for 1875, pp. 96, 97 ; *idem* for 1887, p. 363. Height above O.D. 306 ft.

Well (120 ft. deep, 10 ft. in diameter) and borehole (298 ft. 9 ins. deep and 18 in. in diameter) :—

		Thickness		Depth	
		Ft.	In.	Ft.	In.
[Drift]	Subsoil	2	0	2	0
	Loose sand	1	5	3	5
	Gravel	6	2	9	7
	Running sand	2	8	12	3
[Upper Mottled Sandstone and Pebble Beds]	Sandstone	5	0	17	3
	Running sand		9	18	0
	Sandstone	9	3	27	3
	Running sand	1	9	29	0
	Sandstone	4	3	33	3
	Running sand		11	34	2
	Sandstone	11	10	46	0
	Running sand		9	46	9
	Sandstone	122	8	169	5
	Fissure	1	3	170	8
	Sandstone	71	4	242	0
	Fissure	2	3	244	3
[Enville Group]	Marl	36	0	280	3
	Sandstone	7	5	287	8
	Marl	16	1	303	9
	Sandstone	52	3	356	0
	Sandstone and marl	62	9	418	9

Rest-level.—Overflows. Yield, 3,000,000 gallons per day. Drift waters excluded.

PERRY WELL.

Abandoned as a source of supply: water now pumped into the canal. Communicated by W. Gray, for some time Engineer to the Birmingham Corporation Waterworks. Details obtained from a tracing of a graphic section in the possession of the Waterworks Department. Height above O.D. 315 ft.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Alluvial]	Sand and gravel (dry) ...	8	3	8	3
	,, ,, ,, (wet)	7	9	16	0
[Bunter Pebble Beds]	Red sandstone ('wash' at top)	19	3	35	3
	Sand parting	1	5	36	8
	Red sandstone	12	2	48	10
	Marl parting	1	2	50	0
	Red sandstone	47	0	97	0

Rest-level.—Overflows. Yield, 2,000,000 gallons per day.

KING'S VALE WELL (Near Kettlehouse Farm).

Abandoned. Height above O.D. 454·4 ft.

Well (170 ft. deep, 13 ft. in diameter) and borehole (130 ft., 20 in. in diameter).

NECHELLS BORING.

At the Nechells Gasworks about 200 yards west of the Birmingham Fault. Made for water in 1922 by Messrs. C. Isler & Co., Ltd.

Description by Prof. W. S. Boulton, *Quart. Journ. Geol. Soc.*, vol. lxxx (1924), pp. 345-347.

Height about O.D., 329 feet. Boring (18 in. diameter):—

	Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
Made ground	1	0	1	0
Gravelly drift	54	6	55	6
Red sandstone, coarse, open-textured, and somewhat harder and browner in the lower part, with false-bedding and clay-pellets ...	100	0	155	6
Red marl	1	6	157	0
Red sandstone, with occasional bands of shaly micaceous sandstone, and sandy shale near the base	46	0	203	0
Red and green shaly marl, mixed with sand ...	9	0	212	0
Red sandstone	70	0	282	0
Red sandstone, usually micaceous, with very occasional rounded and flattened pebbles; a few larger angular pebbles (1½ inches across) at 295 feet, and occasional chips at other horizons ... ... (*Base of the Keuper Sandstone.*)	45	6	327	6
Red marl, with partly rounded[1] cobbles of quartzite, and a portion of a larger angular mass of quartzite (14 × 9 inches).	12	6	340	0

[1] The partial rounding is probably due to the grinding action of the boring tools for many days.

	Thickness Ft.	In.	Depth Ft.	In.
Coarse breccia, with angular lumps of siliceous rock, some 9 inches across, and smaller chips of the same material, set in a red sandy marl-matrix	23	0	363	0
Dull-red marly sandstone	6	0	369	0
Coarse breccia, with one angular lump measuring 14 × 11 × 10 inches, being part of a larger mass of hard siliceous sandstone	6	0	375	0
Breccia, with layers of sandstone and finer breccia	5	0	380	0
Coarse breccia, with angular fragments 9 inches across in the lower 4 feet (trilobite-fragments)	10	0	390	0
Dark-red crumply sandstone	9	6	399	6
Marly sandstone, with angular chips up to 4 or 5 inches across	16	6	416	0
Red sandstone	2	0	418	0
Very coarse breccia, with irregular lenticles of marls, and with lumps of hard sandstone up to 11 inches across...	7	0	425	0
Marly sandstone, with bands of fine and coarse breccia	5	0	430	0
Red sandstone	7	0	437	0
Sandstone, with breccia containing subangular rocks	3	0	440	0
Coarse breccia, with lumps of Cambrian limestone containing *Hyolithus*, *Coleoloides*, and brachiopods	21	0	461	0
Coarse breccia, with very angular green and grey quartzite, 6 and 8 inches across, and Cambrian rocks containing *Salterella curvata*, *Coleoloides typicalis* and *Micromitra*, in hard siliceous sandstone	5	0	466	0
Calcareous sandstone, with much haematite staining	4	0	470	0
Breccia, very coarse, with angular lumps and chips of red-purplish calcareous sandstone, often mottled green and red at about 487 feet, yielding *Hyolithus* and *Micromitra*	30	0	500	0
Red sandstone, with rather rounded pebbles of grey-purplish sandstone, up to 7 inches across	8	0	508	0
Coarse breccia, with angular pebbles of marly sandstone (9 × 8 inches) containing *Hyolithus*, trilobite-fragments, *Obolus*, *Strenuella*, *Micromitra*, *Coleoloides*, etc.	42	0	550	0
Finer breccia, harder and more sandy	16	0	566	0
Sandstone	1	0	567	0
Marly breccia	16	0	583	0
Compact breccia, with small calcareous fragments and larger siliceous chips set in calcareous sandstone (*Coleoloides typicalis*) ...	20	0	603	0
Coarse marly breccia, with stones up to 6 inches across, and more rounded limestone-fragments	3	0	606	0
Hard, red, non-calcareous sandstone, with bands of small angular fragments yielding *Micromitra phillipsi*	10	0	616	0

	Thickness Ft.	In.	Depth Ft.	In.
Clayey non-calcareous sandstone, with thin bands of hard sandstone	3	0	619	0
Hard sandstone, with bands of fine conglomerate, the pebbles red, yellow (calcareous), and green, with occasional large angular fragments	12	0	631	0
Dull-red, clayey, non-calcareous sandstone, with thin highly calcareous bands, ferruginous, weathering to a crumbly mass	3	0	634	0
Hard, pale-red, false-bedded, non-calcareous sandstone	2	0	636	0
Compact fine breccia, with occasional fragments up to 6 inches across, some of limestone. Dip about 5°	8	0	644	0
Dull-red, fine, iron-stained conglomerate, with angular and partly-rounded fragments ...	2	6	646	6
Hard grey sandstone	3	6	650	0
Red, sandy, calcareous marl, with no pebbles or chips, and with occasional thin beds of calcareous sandstone	17	0	667	0
Coarse breccia, with large angular lumps of calcareous sandstone up to 9 inches, and very irregularly disposed	1	6	668	6
Marl and laminated marly sandstone	1	3	669	9
Coarse breccia with blocks of calcareous sandstone	7	3	677	0
(*Base of the Breccia.*)				
Yellow-brown, porous, calcareous sandstone, with iron pyrites	5	0	682	0
Dense jaspery conglomerate, with red, yellow, and green rounded pebbles of fairly uniform size ($\frac{3}{4}$ inch across) in a sandy matrix, which is highly calcareous, especially in the lower 4 feet. The alignment of the pebbles and fracture-planes dips at 20°	7	0	689	0
Dark-red calcareous marl, weathering rapidly...	14	0	703	0
Hard, red, calcareous sandstone, the lower part variegated red and green	0	9	712	0
[Below 712 feet, the boring was stopped in dull-red marly material, from which no cores were drawn.]				

Analyses.

Waters from Wells in use.

Analyses made by J. F. Liverseege, F.I.C., F.C.S., City Analyst.

Witton or Short Heath Well :—
1. 1892. Average of three samples.
2. 1907. ,, ,, ,, ,,
3. 1924-25. ,, ,, two ,,

Aston Well :—
4. 1892. Average two samples.
5. 1907. ,, three ,,
6. 1924. Average five samples.
7. 1925. Analysis of one sample.

Longbridge Well :—
8. 1892. Average two samples.
9. 1907. ,, three ,,
10. 1923. ,, two ,,

Parts per 100,000.

	1	2	3	4	5	6	7	8	9	10
Total solid matter	26·3		39·5	29·6	—	47·3	45·0	21·0	—	22·4
Free ammonia	·001	·000	·000	·000	·001	·003	·000	·001	·000	·000
Albuminoid ammonia	·002	·001	·001	·008	·002	·003	·001	·003	·001	·000
Nitrogen in nitrates	·612	1·13	·98	·270	·50	·60	·81	·340	·20	·22
Ph	—	—	7·5	—	—	7·5	7·6	—	—	6·5
Oxygen consumed at 27°C. (80°F.)										
in 4 hours	—	·02	—	—	·03	—	—	—	·03	
3 hours	—	—	0	—	—	·02	·01	—	—	·01
Chlorine in chlorides	1·9	2·3	2·7	3·2	3·2	3·3	3·4	1·0	1·4	1·5
Alkalinity (as $CaCO_3$)	—	8·7	8·1	—	15·2	14·7	14·9	—	12·8	9·2
Hardness : temporary	7·7	—	—	—	—	—	—	—	—	—
permanent	7·7	—	—	—	—	—	—	—	—	—
total	15·4	—	19·0*	21·8	—	—	30·0	12·4	—	—

* 1920

1. Aston Well, May 16, 1873 (pp. 93, 314).
2. Perry Well, May 16, 1873 (pp. 93, 314).
3. Short Heath Well, Witton, May 16, 1873 (pp. 93, 315).
4. King's Vale Well, May 16, 1873 (pp. 93, 315).
5. James's Spring below Witton reservoir, May 16, 1873 (pp. 116, 315).

Sixth Report (1874), Rivers Pollution Commission, pp. 93, 116, 314, 315: also *Rep. Brit. Assoc.* for 1876, pp. 108, 109.

Parts per 100,000.

	1	2	3	4	5
Temperature: centigrade ...	10·8	12·0	10·2	12·5	—
Total solid impurity	19·42	23·24	15·08	18·06	15·54
Organic carbon	·034	·031	·009	·037	·052
Organic nitrogen	·006	·007	·004	·012	·019
Ammonia	0	0	0	0	·001
Nitrogen as nitrates and nitrites	·176	·469	·447	·677	·504
Total combined nitrogen ...	·182	·476	·451	·689	·524
Previous sewage or animal contamination	1,440	4,370	4,150	6,450	4,730
Chlorine	2·00	1·75	1·30	1·80	1·75
Hardness: temporary ...	9·7	7·8	4·6	3·8	0
permanent ...	5·4	6·6	5·1	7·4	8·3
total	15·1	14·4	9·7	11·2	8·3
Remarks	Clear & palatable	Clear & palatable	Clear & palatable	Slightly turbid: palatable	Clear & palatable

Shallow Wells.

Analyses of waters from a number of shallow wells in Birmingham are given on p. 75 of the Sixth Report (1874) Rivers Pollution Commission.

Waters derived, per boreholes, from Triassic sandstones *not covered by Keuper Marl*:—

Analyses by J. F. Liverseege, F.I.C., F.C.S., City Analyst.

740. Birmingham Workhouse, Winson Green. 17th Dec., 1910. Water from deep well.
General Electric Co., Witton.
249. Artesian well. 10th May, 1920.
340. New artesian well. 320 ft. deep. 30th May, 1925.
579. Water taken from borehole. 27th Nov., 1912.
80. Nechells Gas Works. 9th Feb., 1917.

Parts per 100,000

Analyst's refs.	740	249	340	579	80
Total solid matter	15	82	27	62	47
Free ammonia	·000	·000	·000	·000	·120
Albuminoid ammonia ...	·001	·006	·001	·003	·006
Nitrogen as nitrates	0·2	1·7	·90	0·7	0
Nitrogen as nitrites	0	·008	0	·000	·24
Oxygen consumed in 3 hours at 27°C. (80°F.)	·02	·07	·01	· 04	·21
Chlorine as chlorides	1·9	5·3	1·9	3·8	3·0
Alkalinity (as $CaCO_3$) ...	3·9	15·3	10·6	14·0	19·2

Water derived, per boreholes, from Triassic sandstones, *not covered by Keuper Marl.* Analyses made by J. F. Liverseege, F.I.C., F.C.S., City Analyst.

Monument Road Public Baths.—
135. New well, 7th February, 1883.
137. 22nd February, 1883.

Nechells Public Baths.—
192. Borehole pump. 3rd May, 1922.
337. Bottom of well, 25th May, 1910.

Woodcock Street Public Baths.—
219. 1884. 27th September.
339. 1886. 3rd May. Well.
434. 1888. 24th April. Well.
1. 1888. 12th October.

Woodcock Street Public Baths (contd.)—
11. 1888. 12th November.
22. 1888. 29th November. Borehole.
38. 1889. 16th January. Borehole.

Kent Street Public Baths. Close to west side of the Birmingham Fault.—
124. 1924. Water from borehole. 25th Feb.
334. 1918. 10th July.
842. 1911. 4th December.
401. 1905. 15th July.

Analyst's refs.	135	137	192	337	219	339	434	1	11	22[1]	38[2]	124	334	842	401
Total solid matter ...	61·6	27·8	21	27	151	183	187	202	203	208	93	104	116	126	152
Free ammonia	·009	·002	—	—	·020	·004	·080	·040	·040	·060	·004	·001	·002	·001	·002
Albuminoid ammonia ...	·011	·006	—	—	·016	·015	·056	·006	·008	·013	·012	·003	·004	·003	·012
Nitrogen as nitrates ...	1·54	0·77	0	0	4·9	4·0	6·0	8·1	7·9	8·6	3·3	2·7	3·5	4·2	3·8
Nitrogen as nitrites ...	—	—	·002	—	—	—	—	—	—	—	—	0	0	·000	—
Oxygen consumed in 3 hrs. at 27°C. (80°F.)... ...	—	—	—	—	—	—	—	—	—	—	—	·02	·03	·03	·01
Chlorine as chlorides ...	3·2	1·2	1·6	1·8	18·3	13·1	17·2	20·2	20·9	21·2	8·3	13·2	20·6	34·6	35·0
Alkalinity	—	—	16·4	18	—	—	—	—	—	—	—	10·6	11·9	17·2	—
Hardness: permanent ...	13·2	8·4	8	7	—	—	—	—	—	—	—	—	—	—	—
temporary ...	2·8	1·1	7	6	—	—	—	—	—	—	—	—	—	—	—
total	16·0	9·5	15	13	—	—	—	—	—	—	—	—	—	—	—

[1] Fe_2O_3 and Al_2O_3 = ·46 [2] Fe_2O_3 and Al_2O_3 = ·94.

PUBLIC BATHS.

Waters derived, per boreholes, from Triassic sandstones *beneath a covering of Keuper Marl* :—

Analyses made by J. F. Liverseege, F.I.C., F.C.S., City Analyst.

Moseley Road Public Baths (see p. 170).—
115. Sample from well. 22nd February, 1908.
x. Water from borehole. March, 1909.
Saltley Public Baths, George Arthur Road (see p. 169).—
457. Water from borehole of well on site for baths. 19th July, 1913.
461. July 23rd, 1913.
Selly Oak Public Baths, Tiverton Road (see p. 170).—
261. Water from delivery pipe of pumping-plant drawing from borehole. April 27th, 1915.
581. Small Heath Public Baths, Green Lane (see p. 169).—After 3 hours pumping. 2nd Nov., 1905.

Analyst's refs.	115	x[1]	457	461	261	581
Total solid matter	243	236	43	42	234	220
Free ammonia	·018	·028	·001	·021	·011	—
Albuminoid ammonia	·004	·008	·001	·019	·001	—
Nitrogen in nitrates	0	0	0	0	0	0
Nitrogen in nitrites	—	—	—	—	0	—
Oxygen consumed at 27°C. (80°F.) in 4 hours	·02	·01	—	—	—	·01
3 hours	—	—	?	·36	·03	—
Chlorine in chlorides	2·3	3·0	4·8	4·1	2·5	2·0
Alkalinity (as $CaCO_3$)	15·0	16·4	19·6	16·4	19·0	18·0
Hardness : permanent	—	130	12	16	—	(Ca ·42 SO_4 114)
temporary	—	6	10	12	—	—
total	160	136	22	28	140[2]	140

[1] Ferric Oxide 0·3. Sulphate equivalent to 182 parts of Calcium Sulphate.
[2] As $CaCO_3$.

RUBERY HILL ASYLUM.

From deep well. Analyses made by J. F. Liverseege, F.I.C., F.C.S., City Analyst.

326. Deep well. 25th June, 1920.
56. Well. 27th Jan., 1908.
1. Water from bottom of well. 14th Feb., 1905.
154. Well, 1900.
180. Well, 1900.
2x. Direct from well, 1899.
36. 1891.
37. 1891.
38. 1891.

Parts per 100,000.

Analyst's refs.	326	56	1	154	180	2x	36	37	38
Total solid matter	16	16·6	15·2	10·8	2·0	16	10·4	11·4	15·3
Free ammonia	·005	·001	·002	·000	·003	·001	·001	·001	·001
Albuminoid ammonia	·012	·002	·004	·002	·006	·004	·002	·003	·000
Nitrogen in nitrates	0·1	·15	·15	0·1	0·1	0·1	0	0	0
Nitrogen in nitrites	·004	—	—	—	—	—	—	—	—
Oxygen consumed in 3 hours at 27°C. (80°F.)	·02	·05	·02	·01	—	—	—	—	—
Chlorine in chlorides	1·9	1·3	1·4	1·4	1·2	1·4	1·0	1·0	1·0
Alkalinity (as $CaCO_3$)	5·6	7·0	6·6	—	—	—	—	—	—
Hardness	—	—	8·0	6·0	5·5	8·0	—	—	—

Wells and Boreholes for Water.[1]

Note.—A dash (—) indicates lack of information : f^6 signifies Keuper Marl ; f^5, Lower Keuper Sandstone ; f^3, Upper Mottled Sandstone ; f^2, Pebble Beds.

	Name.	Six-inch Map.	Approx. height of surface above O.D. in ft.	Depth in ft.	Standing Water-level in ft. below surface	Yield : gallons per hour (H), day (D), or week (W).	Strata passed through : depth in ft. to base of each formation except lowest.	Remarks.
1.	Ansell's Brewery, Aston Cross. No. 3.	War. 8 S.W.	356	638	—	See No. 19	f^5 under 50, f^3 298, f^2 638	——
2.	Aston Water Works ...	do.	306	419	Overflows	3,000,000 D	Drift 12, f^3 120, f^2 240, Enville Beds, 419	——
3.	Atkinson's Brewery, Aston Park. No. 1.	do.	340	275	33	10,000 H	f^5, f^3 and f^2	Well to 18ft.
	Do. No. 2.	do.	do.	245	31			Well to 30ft.
	Do. No. 3.	do.	do.	350	23½	——	Drift 24, f^5 ?35, f^3 185, f^2 350	
4.	J. & W. Baldwin, Salford Street.	do.	320	130	6	2,000 H	Drift and f^5 ...	Well to 10ft.
5.	Birmingham Electricity Supply Dept., Aston Church Road.	do.	300	518	Overflows slightly	27,000 H	Drift 26½, f^5, f^3 and ? f^2	Strata highly inclined. Water above 208 ft. sealed out.
6.	Messrs. Booth, Argyle Street.	do.	300	201	—	10,000 H	Drift 13, f^5 201 ...	——

[1] Extract from 'Geology of Birmingham' (*Mem. Geol. Surv.*), 1925, pp. 126-137.

	Name.	Six-inch Map.	Approx. height of surface above O.D. in ft.	Depth in ft.	Standing Water-level in ft. below surface	Yield : gallons per hour (H), day (D), or week (W).	Strata passed through : depth in ft. to base of each formation except lowest.	Remarks.
7.	Dunlop Rubber Co. Ltd., Manor Mills.	War. 8 S.E.	300	350	20 to 28	18,360 H	Drift 18, f^5 110, f^3 205, f^2 350	Water-level drops to 70 ft. when pumping.
8.	Erdington Laundry ...	do.	400	200	45 to 50	Abundant	Drift 30, f^5 200 ...	Well to 50 ft.
9.	General Electric Co., Witton	do.	?300	75	—	22,000 H	Drift 14, f^3 75 ...	——
10.	Hughes Stubbs Metal Co. Ltd., Plume Street.	do.	320	350	—	13,000 H	Drift 17½, Trias 239, Hopwas 350	Trias probably all f^5. Standing water-level at a small well on same premises : 8 ft.
11.	Kynoch's Lion Works, Witton.	do.	?320	300	4	?18,000 H	Peat 3, f^3 300 ...	Well to 9 ft.
12.	Kynoch's Holford Works, Perry Barr.	do.	?320	231½	3	——	Drift 18, f^3 188, f^2 231½	——
13.	Midland Railway Carriage and Wagon Co. Ltd., Washwood Heath.	do.	295	650	40	——	Drift 69, f^6 190, f^5 650	Water above 266 ft. sealed out.
14.	Perry Well, Birmingham Water Works.	do.	315	97	Overflows	2,000,000 D	Alluvium 16, f^2 97	——

15.	Messrs. Quilter, Aston Park.	do.	360	195	20	3,000 H	f^3 195	Well to 8 ft.
16.	Smith's Brewery, Lichfield Road.	do.	340	118	—	50,000 to 60,000 D	Drift 15, f^5 118 ...	Well to 18 ft.
17.	A. Wills & Son, Park Mills...	do.	200	200	16	3,600 H	Drift 24, f^5 200 ...	——
18.	Dunlop Rubber Co. Ltd., Birches Green, Erdington.	do.	290	677	Surface	22,000 H	Alluvium 11, f^6 164, f^5 & f^3 482, f^2 677	Water-level 46 ft. After 72 hours pumping.
19.	Ansell's Brewery, Aston Cross. No. 1.	War 14. N.W.	350	533½	—	300,000 D from three bore-holes	——	Water above 217½ ft. sealed out.
20.	Ansell's Brewery, Aston Cross. No. 4	do.	350	670	75	See No. 19	f^5 less than 100, f^3 307, f^2 ?658, ?Enville Beds 670,	——
21.	Birmingham Co-operative Dairies, Vauxhall Road.	do.	350	350	62	—	Drift 10, f^6 76, f^5 350	Lined to 204 ft.
22.	British Oxygen Co. Ltd., Saltley.	do.	305	251½	—	10,000 H	Alluvium and Drift 94, f^5 251½	——
23.	Buttons Ltd.. Portland Street.	do.	330	300	—	5,850 H	Drift 15, f^5 250, ?f^3 300	Lined to 100 ft.
24.	C.A.M.W.A.L., Rocky Lane	do.	325	220	11	1,200 H	Drift 26, f^5 220 ...	Water above 135 ft. sealed out.

	Name.	Six-inch Map.	Approx. height of surface above O.D. in ft.	Depth in ft.	Standing Water-level in ft. below surface	Yield : gallons per hour (H), day (D), or week (W).	Strata passed through : depth in ft. to base of each formation except lowest.	Remarks.
25.	Clifford's Rolling Mills, Fazeley Street.	War. 14 N.W.	350	250	68	2,640 H	Drift 38, f^5 250 ...	On Birmingham Fault; strata highly inclined. Lined to 100 ft.
26.	Wm. Cooper & Goode Ltd., Bradford Street.	do.	340	650	—	—	Drift 34½, f^6 271½, f^5 ?429½, f^2 650.	Well to 16 ft.
27.	County Chemical Co. Ltd., Bradford Street.	do.	340	304½	55	—	Drift 39, f^6 304½ ...	Lined to 122½ ft.
28.	Messrs. Cox, Aston Road ...	do.	340	175	15	5,000 H	Drift 110, f^5 162, f^3 175	Well to 8 ft.
29.	Davenport's C. B. Ltd., Bath Road.	do.	470	678	—	—	Drift 23, f^5 367, f^3 569, f^2 666, Enville Beds 678	Well to 26 ft.
30.	Deritend Stamping Co. Ltd., Liverpool Street.	do.	340	100	—	1,000 H	Drift 68, f^6 100 ...	Lined to 50 ft.
31.	Dunlop Rubber Co., Aston Cross.	do.	340	658	—	20,000 H	Drift 19, f^5 146, f^3 330, f^2 511, Enville Beds, 658	Well to 14 ft.

32.	Fardon's Vinegar Brewery, Glover Street.	do.	340	329	47	—	Drift less than 50, f⁶ 274, f⁵ 329	Well to 60 ft.
33.	The Grand Hotel, Colmore Row.	do.	430	585	71	4,000 H	No details of strata. Probably in f² at bottom	——
34.	Messrs. Hawkes, Bromsgrove Street.	do.	380	402	—	—	Drift 17, f⁵ 402 ...	Near Birmingham Fault; strata probably inclined.
35.	Messrs. Hill, Hampton Street.	do.	400	212	74	1,000 H	Drift 90½, f³ 212 ...	——
36.	Messrs. Hinks, Aston Road	do.	350	240	—	3,000 H	Drift 60, f⁵ 240	Well to 18 ft.
37.	Holbrooks Ltd., Ashted Row	do.	380	300	51½	—	Drift 50, f⁵ 300 ...	Lined to 200 ft.
38.	Kenway's Ltd., Moor Street	do.	400	250	—	6,000 H	Drift 13, f⁵ 250 ...	——
39.	Lightfoot Refrigerating Co. Ltd., Digbeth.	do.	350	282	6 ins. above surface	Abundant	f⁵ 282	Near Birmingham Fault; strata probably inclined.
40.	Marsh & Baxter, Dale End	do.	400	304	51	——	Drift 56, f⁵ 304 ...	Lined to 198 ft.
41.	Metropolitan Carriage, Wagon and Finance Co. Ltd., Saltley.	do.	310	300	11	10,000 H	Sand and gravel 10, Boulder-clay 41, f⁶ 128, f⁵ 300	——
42.	Midland Hotel, Stephenson Street.	do.	420	505	—	——	Drift ?, f⁵ 109, f³ 375, f² 505	Well to 12 ft.

Name.	Six-inch Map.	Approx. height of surface above O.D. in ft.	Depth in ft.	Standing Water-level in ft. below surface	Yield : gallons per hour (H), day (D), or week (W).	Strata passed through : depth in ft. to base of each formation except lowest.	Remarks.
43. Midland Vinegar Co. Ltd., Aston Cross.	War. 14 N.W.	350	677	—	7,500 H	f^5 ?50, f^3 322½, f^2 ?655, Enville Beds 677.	Water pumped from a depth of 280ft.
44. Nechells Gas Works, 1922 Well.	do.	350	718	21	20,000 H	Drift 55½, f^5 327½ ? Hopwas Breccia 677, Enville Beds (Calc. Congl. Group), 718.	——
45. Nechells Gas Works, Devon Street.	do.	320	465	—	6,000 H	——	Well to 60 ft.
46. Nechells Public Baths, Aston Church Road.	do.	350	520	—	—	Drift, 33½, f^5 124, f^3 242, f^2 520	Well to 58 ft.
47. Parsons & Co., Miller Street	do.	360	224	—	4,250 H	Drift 17, f^3 224 ...	Well to 8 ft.
48. Perry & Co., Lancaster Street.	do.	390	300	52	8,000 H	Drift 72, f^5 137, ?f^3 300	Well to 57 ft.
49. Rushton's Brewery, Aston Road.	do.	340	400	32½	10,000 H	Drift 16, f^5 196½, f^3 330, f^2 400	——
50. Saltley Gas Works, Duddeston Mill Road.	do.	310	602	32	20,000 H	Drift ? f^6 86, f^5 ? 515, f^2 602	——

51.	Saltley Public Baths, George Arthur Road.	do.	330	?500	—	—	Drift 15, f⁶ 124, f⁵500	——
52.	Showell's Bottling Stores, Bordesley Street.	do.	355	250	9	—	Drift 34, ? f⁵ 250 ...	Near Birmingham Fault.
53.	Smart & Sons Ltd., Fazeley Street.	do.	340	727	—	13,000 to 15,000 H	Alluvium and Drift 66, f⁵ ?379, f² 727	——
54.	Small Heath Public Baths, Green Lane.	do.	430	624	130	10,000 H	Drift 25½, f⁶ 413, f⁵ 624	Well to 170 ft.
55.	Tailby's Bottling Stores, Bordesley Street	do.	340	419	8	1,700 H	Drift 30, f⁵ 419 ...	Near Birmingham Fault; strata highly inclined.
56.	Warne & Wright & Rowland Ltd., New Bond Street.	do.	350	142½	—	No water	Drift 92, f⁶ 142½ ...	——
57.	White Bros. Ltd., Aston Brook Street.	do.	340	250	—	5,000 H	Alluvium and Drift 135, f³ 250	——
58.	Windsor Street Gas Works.	do.	340	600	50	—	Drift 41½, f⁵ ?150, f³ 329, f² ?504, ? Enville Beds 600	Record of strata doubtful.
59.	Wolseley Motor Works, Saltley.	do.	390	410	—	Abundant	No details. f⁶ 410	Information not quite certain.
60.	Alldays & Onions Ltd., Sydenham Road.	War. 14 S.W.	380	836½	87	—	f⁶ 362, f⁵ ?725½, f² 836½	Water above 700 ft. sealed out.

	Name.	Six-inch Map.	Approx. height of surface above O.D. in ft.	Depth in ft.	Standing Water-level in ft. below surface	Yield : gallons per hour (H), day (D), or week (W).	Strata passed through : depth in ft. to base of each formation except lowest.	Remarks.
61.	Dare & Son, Ltd. Highgate Street.	War. 14 S.W.	360	682½	—	3,500 H	f⁶ 252, f⁵ 682½ ...	——
62.	Moseley Road Public Baths	do.	425	727½	102	8,000 H	f⁶ 484, f⁵ 727½ ...	Well to 174 ft.
63.	Women's Hospital, Showell Green Lane.	do.	420	700	—	—	Drift 7, f⁶ 465, f⁵ 700	Record not complete.
64.	Bate's Brewery, High Street, King's Heath.	War. 19 N.W.	500	1,106½	184	Plentiful	Drift 56, f⁶ 603, f⁵ 928, f² (or f³) 1106½	Well to 32 ft. Building now demolished.
65.	Elliott's Metal Co. Ltd., Selly Oak.	Wor. 10 N.E.	?480	703½	82	9,000 H	Drift ?, f⁶ 366½, f⁵ 703½	Record doubtful.
66.	Fernihough's Dairy, Hubert Road.	do.	430	490	158 (pumping)	2,280 H	Drift 32, f⁶ ?388, f⁵ 490	——
67.	Selly Oak Public Baths, Tiverton Road.	do.	430	450	34	80,000 to 90,000 D	Drift 1½, f⁶ 440, f⁵ 450	——
68.	Stirchley Street Public Baths	do.	415	582	—	No water	Drift 15, f⁶ 582 ...	——
69.	T. Shaw & Sons, Ltd., Burbury Street, Lozells.	Staff. 68 S.E.	400	220	80	—	Drift 72, ? f³ 220 ...	——

70.	Birmingham Railway Carriage and Wagon Co. Ltd., Smethwick.	do	440	660	8	6,000 H	Drift ? 34, f² ? 67, Enville and Keele 660	——
71.	R. A. Price (now G. J. Mason), Thynne Street, West Bromwich.	Staff. 68 S.W.	560	398	76	2,000 H	Drift 38, Keele 398. ...	Well to 14 ft.
72.	A. Powell & Sons, Victoria Street, West Bromwich.	Staff. 68 S.W.	540	200	54	720 H	Drift ?, Keele 174, Halesowen 200	Well to 61 ft.
73.	Henry Bates, Spon Lane, West Bromwich.	do.	500	357	—	1,000 H	Drift 32, Keele 357	Well to 6 ft.
74.	Birmingham Battery & Metal Co., Selly Oak.	Staff. 72 S.E. (War. 13 S.E. Wor. 5 S.E.)	460	250	35	21,523 H	Drift 36, f³ & f² 250	——
75.	Selly Oak Pumping Station, Birmingham Waterworks.	do.	450	120 (about)	—	500,000 to 1,000,000 D	Drift ?10 to 20, f³ 120	Abandoned owing to pollution.
76.	Harborne Public Baths ...	do.	568	482	—	—	Drift 69, f² 291, Enville Beds 482	——
77.	Smethwick Gas Works, Rabone Lane	Staff. 72 N.E. (War. 13 N.E., Wor. 5 N.E.)	450	300	—	—	Drift 56, f³ 102, f² 300	——

	Name.	Six-inch Map.	Approx. height of surface above O.D. in ft.	Depth in ft.	Standing Water-level in ft. below surface	Yield : gallons per hour (H), day (D), or week (W).	Strata passed through : depth in ft. to base of each formation except lowest.	Remarks.
78.	Smethwick Laundry, Dale Street.	Staff. 72 N.E. (War. 13 N.E., Wor. 5 N.E.)	550	201	62	1,250 H	Alluvium 22, f³ 91, f² 201	——
79.	Cheshire's Brewery, Windmill Lane .	do.	550	300	140	7,000 H	Drift 48, f³ 300 ...	——
80.	District Iron & Steel Works, Smethwick	do.	520	313	70	1,200 H	Drift ?16, f² 87, Enville beds 313	——
81.	Allan & Everitt, Rolfe Bridge, Smethwick.	do.	450	300	54	—	Drift 33, f² & Enville Beds 300	——
82.	Mitchells & Butlers, Cape Hill Brewery, No. 1.	do.	500	302	96	8,000 H	Drift 47, f³ 109, f² 302	——
83.	Do. No. 2.	do.	500	412	96	8,000 H	Drift 50, f³ and f² 412	——
84.	Do. No. 3.	do.	470	558	97	——	Drift 61, f³, f² and Enville Beds 558	——
85.	Guest, Keen & Nettlefolds, Ltd., Smethwick.	do.	470	400	20	12,000 H	Drift 75, f³ 200, f² ?400	——

86.	Tangyes, Ltd., Cornwall Works, Smethwick.	do.	450	301	86½	15,000 H	Drift 53½, f³ 108, f² 301	——
87.	R. White & Sons, Western Road.	do.	460	368	83	15,000 H	Drift 79, f³ and f² 368	——
88.	Birmingham Workhouse, Winson Green.	do.	470	560	124	About 4,000 H	Drift 100, f³ and f² 560	Rest - level in 1901, 105 ft.; in 1918, 124 ft.
89.	Vivian & Co., Icknield Port Road.	do.	470	327	93	3,360 H	Drift 24, f³ and f² 327	——
90.	S. White's Brewery, Winson Street.	do.	500	300	95	1,680 H	Drift 70, f³ and f² 300	——
91.	Barker & Allen Ltd., Spring Hill.	do.	460	400	110	6,714 H	Drift 70, f³ and f² 400	——
92.	Earle Bourne & Co., Spring Hill.	do.	460	458	109	12,000 H	Drift 90, f³ 348, f² 458	——
93.	Cattell Bros., 392, Farm Street.	do.	400	160	38	1,800 H	Drift 38, f³ 160 ...	——
94.	A. W. Gurden, 349, Monument Road.	do.	520	350	135	2,000 H	Drift 80, f³ 221, f² 350	——
95.	L.M.S. Rly. Loco. Sheds, St. Vincent Street.	do.	450	500	62	7,600 H	f³ and f²	——

	Name.	Six-inch Map.	Approx. height of surface above O.D. in ft.	Depth in ft.	Standing Water-level in ft. below surface.	Yield: gallons per hour (H), day (D), or Week (W).	Strata passed through: depth in ft. to base of each formation except lowest.	Remarks.
96.	Watson, Todd & Co., Midland Flour Mills, St. Vincent Street.	Staff. 72 N.E. (War. 13 N.E., Wor. 5 N.E.	450	400	—	11,000 H	f^3 and f^2	Well to 75 ft.
97.	Myatt & Co., Graham Street	do.	450	350	106	1,300 H	Drift ?10, f^3 & f^2 350...	Well to 80 ft.
98.	S. Jessop, King Edward's Road.	do.	440	250	64	2,000 H	f^3	——
99.	The Mint, Icknield Street ...	do.	400	641	16	10,000 to 20,000 H	f^3, f^2 & ? Enville Beds	Well to 43 ft. Old borehole to 328 ft.
100.	Edgbaston Pumping Station, Birmingham Waterworks.	do.	500	270	—	—	Drift 113½, f^3 270 ...	——
101.	Hockley Station, G.W. Railway.	do.	430	514	90	—	Drift 76, f^3 ?189, f^2 ?242, Enville Beds (Calc. Cong. Group) 514	——

County Borough of Coventry

The geology of the greater part of Coventry is shown on the 1-inch Geological Survey Map, New Series, Sheet 169 ; the lesser —southern—part on Old Series, Sheet 53 N.W. The 6-inch maps, with geological boundaries determined during the resurvey, namely 21 N.E., S.E., 22 N.W., S.W., are, however, available for the whole. It is therefore unnecessary to go into details of the geology here : it will suffice to say that the greater part of the city is on Enville Beds including the Corley Sandstones and Conglomerates. The outcrop of these Corley beds passes through the city from north-west by north to south-east by south and their water-bearing properties in no small measure determined the site of the town. The outcrop commences at Corley and is some $4\frac{1}{2}$ square miles in area. It was the fact that the Spon End Supply was dependent upon this area which caused the City Council to oppose the Nuneaton Corporation when the latter proposed sinking a well in the same strata at Corley. It also actuated the Council in acquiring the North Warwickshire Water Company's undertaking, and there was also the advantage that the Company had wide powers which enabled them to sink wells in any locality in an extensive area. The capacity of the Corley beds has been estimated at about 1,800,000 gallons per day.

The history of the ancient conduits, wells, pumps, etc., of Coventry—the sources of supply previous to the opening of the Spon End Waterworks towards the close of 1847, has been given in the 1870 edition of B. Poole's ' Coventry : Its History and Antiquities ', pp. 339-343, and to that account the reader is referred.

Ranger, Wm., C.E., in his ' Report to the General Board of Health on a Preliminary Inquiry into the . . . Supply of Water . . . of Coventry ' (1849), dealt with the geographical and geological features of the locality and with the water supply, but the information given under the last heading is chiefly concerned with scales of charges and regulations. He described the Waterworks (p. 10) as " . . . consisting of a reservoir, engine house, etc. [which] have only been recently constructed . . .". He recommended (p. 24) that powers should be taken by the town authority for purchasing the Waterworks.

E. J. Purnell, in his ' Description of the Coventry Waterworks ', published in 1876, said " The water supply of Coventry is derived from four artesian wells [at Spon End] . . . Two of these wells are 75 feet deep : one [completed Nov., 1856], 195 feet ; and one [completed Sept., 1860] 300 feet . . .

In addition to this about 60,000 gallons per day are obtained from two surface springs, and about 60,000 gallons per day from a small brook, called the Barley Brook, which is filtered before use."[1]

[1] *Proc. Assoc. Mun. and San. Eng. and Surveyors*, vol. ii, 1874-75 (1876), p. 156.

Additions to the sources of supply have resulted in the present-time position being as follows :—

Corporation Waterworks[1]

Works (at Spon End) commenced in the early part of 1846 and completed towards the close of 1847.

Supply Coventry County Borough ; parts of parishes of Holy Trinity Without, St. Michael Without (Coventry R.D.) ; Binley, Exhall*, Foleshill*, Keresley, Stoke, Walsgrave-on-Sowe, Wyken (Foleshill R.D.) ; Allesley*, Corley*, Coundon*, Hampton in Arden*, Meriden* (Meriden R.D.) ; Barston*, Knowle, Packwood (Solihull R.D.) ; Baginton, Stoneleigh (Warwick R.D.).

Sources of Supply.—(1) Wells and boreholes at Spon End, Coventry ; (2) Wells and headings at Whitley, Coventry ; (3) Supply in bulk from Birmingham Town Council ; (4) Borehole, (360 ft. deep) Watery Lane, Keresley (*olim* N. War. Water Co.) ; (5) Newland House Well (97·6 ft. deep), near Corley Rocks, Corley (Ditto) ; (6) Keresley Colliery (Shaft), Keresley (Ditto).

The average daily quantity of water derived from each source is, respectively :—

(1) 958,524 gallons ; (2) 811,460 gallons ; (3) 1,276,000 gallons, and a further 1,724,000 gallons per day could be obtained ; (4) 100,000 gallons ; (5) Not constant but at periods of the year about 70,000 gallons per day can be obtained ; (6) 300,000 and a further 200,000 gallons per day could be obtained.

[1] Includes the undertaking lately owned by the North Warwickshire Waterworks Company and purchased by the Corporation on 21st September, 1921.

*Supplied by the North Warwickshire Waterworks Company at the time of its purchase by the Coventry T. C.

Spon End Pumping Station Wells. See ' Coventry Memoir,' p. 129.

Boring.	Position.	Height above O.D. (in feet).	Depth in feet.	Water-level (rest).	Yield (gals. per 24 hours)	Geological Horizon	Remarks.
No. 1 (1855)	From bottom of storage tank	270	195	Surface	—	Corley Conglomerate	The three together yield 600,000 gals. in 24 hours.
No. 2 (1860)	20 ft. outside the limit of the tank	270	300	Do.	—	Do.	
No. 3 (1859)	——	270	307	Do.	—	Do.	
No. 5 (1875)	From bottom of storage tank	270	422	Do.	160,000	Do. and lower part of Corley beds.	Well to 50 ft.; B.H. 24 to 18 in. diam. Saline water at bottom plugged out.
' New Well ' (1888) (also called the ' Doe Bank Well.')	199 ft. N.N.W. of storage tank	270	575	Do.	—	Do.	Water from bottom 10 ft. being stopped out.

The above ' artesian springs ' feed the supply tank at the rate of 1,000,000 gallons per day, from which the pumps force the water to the mains.

SPON END WATERWORKS.

No. 5 Boring, made in 1875 about 119 ft. distant from No. 2 Boring. W. Andrews, *Proc. Warwickshire Nat. and Arch. F. C.* for 1880, p. 29 (copy of section in possession of the Coventry Corporation).

		Thickness Ft.	Depth Ft.
	Depth of reservoir	16	16
	Marl	50	66
	Rock	6	72
	Marl	7	79
	Sandstone	20	99
	Marl	10	109
	Hard sand-rock	25	134
	Marl	6	140
	Hard rock with pebbles ...	20	160
	Marl	14	174
	Hard rock	3	179
	Marl	4	181
	Soft rock...	5	186
[Corley	Marl	3	189
Conglomerate	Rock	3	192
and lower	Marl	2	194
part of Cor-	Rock	7	201
ley Beds	Marl	32	233
(Enville	Hard rock	20	253
Group)]	Marl	2	255
	Rock	9	264
	Marl	3	267
	Rock	7	274
	Yellow sand-rock	23	297
	Marl	2	299
	Rock	9	308
	Marl	3	311
	Hard rock	28	339
	Marl	14	353
	Rock	18	371
	Marl	10	381
	White sand-rock with water at 410 ft....	48	429
	Marl	1	430

Particulars of the strata penetrated by boreholes Nos. 1, 2, and 5, and by the ' New Well ', were communicated by W. Andrews to C. E. de Rance and published in *Rep. Brit. Assoc.* for 1890, pp. 368-374[1]. They differ in detail; but as boreholes and ' Well ' are close together only the records of Borehole No. 5 and of the ' New Well ' are reproduced here.

[1] *See* also *Rep. Brit. Assoc.* for 1876, p. 96. Section of ' Third Well ' (No. 2) is given in *Rep. Brit. Assoc.* for 1878, p. 389.

Spon End Pumping Station. 'New Well'. Coventry Corporation Waterworks.

W. Andrews, *Proc. Warwickshire Nat. and Arch. F. C.* for 1889, pp. 27-30.

		Thickness Ft.	Depth Ft.
	Well.—		
	Soil	1	1
	Mottled marl	8	9
	Hard mottled shale	½	9½
	Mottled marl	7½	17
	Hard white sandstone with mica sparkles	1	18
	Hard red marl	2	20
	Hard brown sandstone with crystalline lustre	1¼	21¼
	Softer red marl	4¾	26
	Hard mottled sandstone ...	½	26½
	,, ,, marl	1½	28
	,, ,, sandstone ...	1	29
	Hard red sandy marl	1	30
	Hard white or mottled sandstone	1½	31½
	Hard red marl	2½	34
	Hard grey sandstone	1½	35½
	Hard white ,, ...	1½	37
	Very hard red marl	4	41
	Coarse hard red sandstone ...	7	48
	Soft red sandstone, bottom of well, dip south 1 in 18 ...	2	50
[Corley Conglomerate and lower part of Corley Beds (Enville Group)]	Borehole.—		
	Hard pebbly conglomerate ...	22	72
	Softer ,, ,, ...	5	77
	Hard buff coloured sandstone...	3	80
	Soft mottled sandstone ...	1	81
	Hard pebbly conglomerate ...	2	83
	Red marl	3	86
	Red sandstone	5	91
	Hard red marl	21	112
	Pale red sandstone	13	125
	Mottled marl	6	131
	Red sandstone with water ...	4	135
	Grey sandstone, full of black specks, water	2	137
	Red marl	27	164
	Red sandstone	4	168
	Hard conglomerate	14	182
	Red sandstone, with water ...	16	198
	Red marl	1	199
	Soft red sandstone	3	202
	Red marl	9	211
	Dark red sandstone	8	219
	Coarse red sandstone grit ...	20	239
	Hard conglomerate	7	246
	Yellow sandstone	1	247
	Red and yellow marls ...	1½	248½
	Hard conglomerate	1½	250
	Red marl	1	251

		Thickness Ft.	Depth Ft.
[Corley Conglomerate and lower part of Corley Beds (Enville Group)]	Red sandstone	3	254
	Hard conglomerate	8	262
	Red sandstone	4	266
	Hard red marl	2	268
	Red sandstone	4	272
	Red marl	2	274
	Very hard red sandstone ...	6	280
	Red sandy marl...	10	290
	Red marl	3	293
	Red sandstone	11	304
	Hard red marl	2	306
	Red sandstone	4	310
	Reddish-yellow sandstone, water	11	321
	Red sandy marl, with white specks	11	332
	Hard red marl	2	334
	Hard red conglomerate ...	2	336
	Hard brown and white mottled sandstone	6	342
	Red marl with ' fish-eyes ' ...	58	400
	Mottled marl	2	402
	White sandstone	3	405
	Red ,, ...	12	417
	Hard grey sandstone	1	418
	Mottled marl	½	418½
	Reddish-grey sandstone ...	5	423½
	White sandstone	2½	426
	Red marl	6	432
	Hard red sandy marl	2	434
	Hard conglomerate	20	454
	Hard coarse white grit	3	457
	Hard red sandy marl	3	460
	Greyish-red sandstone	12	472
	Red sandstone	14	486
	Red marl with ' fish-eyes ' ...	79	565
	Red sandstone	10	575

W. Andrews states (p. 27) :—" Water was tapped at once, and rose to the surface by artesian pressure. The strata were found to be fully charged with water to a depth of about 350 feet, below which no more was obtained till the bottom of the hole was reached."

On page 30: " The boring proceeded, and in the early spring of 1888 had reached a depth of 575 feet. I had been expecting every day to see the Coal Measures reached, but at this depth saline water was tapped. . . . The lower portion of the borehole to the extent of 149 feet was therefore rammed with clay, and the mineral water shut out, and the supply from the upper 426 feet is now used for the supply of the city ".

Analyses of the saline water are given on page 185.

Coventry Electricity Department

Longford Boring. Made to obtain water for the Generating Station being built at Hawkesbury. The classification of the strata was made by Dr. T. Robertson, who examined the cores in July, 1927.

		Thickness Ft.	In.	Depth Ft.	In.
	Soil	1	0	1	0
Superficial.	Red marl with stones	1	6	2	6
	Red and blue marl	9	6	12	0
	Red marl	2	0	14	0
	Dry green sand	1	0	15	0
	Red and blue marl	7	6	22	6
	Dark brown shale	3	6	26	0
Lower	Green sand	1	0	27	0
Keuper	Red and blue marl	7	0	34	0
Sandstone	Dark brown shale	1	0	35	0
(not seen)	Red marl	10	0	45	0
	Hard brown shale	1	0	46	0
	Red and blue marl	6	0	52	0
	Red sandstone	2	0	54	0
	Green rock	1	0	55	0
	Red and blue marl	6	0	61	0
	Blue marl	9	0	70	0
	Hard green rock	3	0	73	0
Halesowen	Blue shale	12	0	85	0
Group	Grey sandstone	6	0	91	0
	Blue clay	1	0	92	0
	Grey sandstone	118	0	210	0
	Blue shale	25	0	235	0
	Soft brown marl	4	0	239	0
	Blue shale	12	0	251	0
	Soft brown marl, with veins of coal worn away	5	0	256	0
	Hard blue shale	6	0	262	0
	Mottled red and green sandstone	5	0	267	0
	Red and blue marl	5	0	272	0
	Blue shale	18	0	290	0
	Brown marl	1	0	291	0
Etruria	Red and blue marl	9	0	300	0
Marl	Brown marl	3	0	303	0
	Blue shale	10	0	313	0
	Red and blue shale	3	0	316	0
	Blue shale	8	0	324	0
	Sandy blue shale	11	0	335	0
	Grey sandstone	18	0	353	0
	Red and blue shale	5	0	358	0
	Brown shale	1	0	359	0
	Red and blue shale	3	0	362	0
	Dark blue shale	2	0	364	0
	Sand [brown, running] ...	3	0	367	0
	Fireclay with stones	3	0	370	0
	Blue shale	9	0	379	0
	Fine grained pale blue sandstone	8	0	387	0
Productive	No core	12	0	399	0
Coal	Pale grey quartz grit		6	399	6
Measures	Fine grained pale blue sandstone	1	6	401	0

Inclination of beds 11°. Standing water-level 62 ft. from surface. Completed diameter 10 in., plugged below 210 ft. The grey sandstone between 92 ft. and 210 ft. is the source of supply. 10,000 gallons an hour were pumped on test with a 4 in. pump, but this is not the total capacity.

ANALYSIS.

Water from the Longford well at the depth of 209 ft. 29.3.27.

	In parts per 100,000
Total solid matter dried at 212°F.	168·0
Oxygen absorbed in 4 hours at 80°F.	0·059
Chlorine in chlorides	45·4
Free and saline ammonia	0·0184
Nitrogen in nitrates and nitrites	nil of either
Organic ammonia	0·0108
Hardness { Temporary ...	38·0
Hardness { Permanent ...	28·0
Hardness { Total	66·0

Appearance, bright, clear. No colour in 2 ft. tube. No smell at 100°F.

Remarks.—Although the ' ammonia ' figures are high there is no nitrate or nitrite and so pollution may be discounted. The water is extremely hard and contains a large amount of common salt in solution, which is due to the district.

(sd.) C. B. O. JONES,
Analytical Chemist.

WILLENHALL BRIDGE BORING.

[Made in 1889 ?. A trial boring made previous to the sinking of the Whitley Well.]

W. Andrews, *Proc. Warwickshire Nat. and Arch. F. C.* for 1889, pp. 30-32. See also *Rep. Brit. Assoc.* for 1891, pp. 210, 311.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
	1. Alluvial sand and gravel	9	0	9	0
	2. Red clay	4	0	13	0
	3. Sand	1	0	14	0
[Lower Keuper Sandstone]	4. White sandstone	13	6	27	6
[Lower Keuper Sandstone]	5. Red ,, ...	1	0	28	6
[Lower Keuper Sandstone]	6. White ,, ...	12	2	40	8
	7. Red marl	10	0	50	8
	8. Red brown sandstone ...	10	2	60	10
	9. Red marl	2	10	63	8
	10. Red sandstone	8	0	71	8
	11. Red marl	1	6	73	2
	12. Red brown sandstone ...	10	10	84	0
[Corley Conglomerate.]	13. Sandstone, with conglomerate	2	4	86	4
[Corley Conglomerate.]	14. Hard conglomerate ...	11	8	98	0
	15. Red and mottled marl ...	10	0	108	0
	16. Red sandstone	14	0	122	0
	17. Red marl	38	0	160	0
	18. Red sandstone	26	6	186	6
	19. Hard conglomerate ...	2	6	189	0
	20. Red marl	11	0	200	0

Andrews said that beds 4-6 were nearly horizontal and that beds 7-20 had a dip of 15°: also that ". . . water was tapped the moment the White Sandstone was reached at 14 feet from the surface. It rose to the surface by artesian pressure and when the bottom of the White Sandstone at 40 feet deep was reached there was

an overflow of about 50,000 gallons per day. Lower down a further supply was obtained in the Permian strata, and the outflow is now [about 1889] stated to be 80,000 gallons per day".

WHITLEY WELL.

Made in 1895. (The thicknesses of the strata given below have been scaled off a chart supplied by the Water Department of the Coventry Corporation.)

Height above O.D., 224 ft.

Well (150 ft.), boring (105 ft.); total, 255 ft. :—

		Thickness		Depth	
		Ft.	In.	Ft.	In.
[Loam, etc., and Lower Keuper Sandstone]	[Loam, etc.]	8	0	8	0
	Sand	2	6	10	6
	[Undescribed]	1	3	11	9
	Red marl and veins of sand ...	4	3	16	0
	Hard white sandstone ...	16	3	32	3
	Red marl with veins of rock ...	14	9	47	0
	Hard white sandstone	13	3	60	3
	Red sandstone	2	3	62	6
[Corley Conglomerate.]	Conglomerate	3	6	66	0
	Marl	2	0	68	0
	Red sandstone and pebbles ...	16	4	84	4
	[Undescribed]	2	2	86	6
	Red sandstone with partings of red marl	7	3	93	9
	Red and yellow sandstone and pebbles	14	3	108	0
	Conglomerate with red sandstone at bottom	12	0	120	0
	Marl	11	3	131	3
	Red sandstone	23	9	155	0
	Red sandstone	5	9	160	9
	White sandstone		9	161	6
	Red marl	2	9	164	3
	Conglomerate	1	6	165	9
	Red marl		9	166	6
	White sandstone	1	3	167	9
	Red marl	7	3	175	0
	Red sandstone	20	0	195	0
	Red marl	2	3	197	3
	Yellowish red sandstone ...	6	6	203	9
	Conglomerate		9	204	6
	Red marl	1	3	205	9
	Conglomerate	3	3	209	0
	Red sandstone	7	0	216	0
	Red marl	11	6	227	6
	Red sandstone	17	0	244	6
	Marl and sandstone	11	6	255	0

Two headings at 60 ft. down: one south; the other in a northerly direction. There was another heading from the bottom of the well, but this has been plugged out.

Rest-level, 100 ft. below surface. Yield, 960,000 gallons per 24 hours.

F. T. Maidwell said (*Proc. Warwickshire Nat. and Arch. F. C.* for 1910, p. 6.) :—" Between the Keuper Sandstone and the red rocks below was an irregular bed of pebbles and marl ". And on p. 7, the constituents included " occasional masses or blocks of calcareous conglomerate, similar to the ' Permian ' conglomerate ". He classed the ' irregular bed ' with the Keuper.

'NEWLAND HOUSE WELL'.

Formerly North Warwickshire Waterworks Co., now Coventry C.C. Near Corley Rock at the Pumping Station on Plot No. 377 Ordnance Survey Map, 25-inch scale (1923 ed.).

Height above O.D., 424 ft.

Lower part of Corley Beds between Corley and Exhall Conglomerates	97·6 ft.

WATERY LANE WELL AND BORING.

Formerly North Warwickshire Waterworks Co. Height above O.D., 360 ft.

Lower part of Corley Beds between Corley and Exhall Conglomerates	360 ft.

KERESLEY COLLIERY.

Particulars communicated by J. W. Liddell, Manager, Keresley Colliery.

	Thickness Ft.	Depth Ft.	Quantity of Water found during sinking.	
			Gallons per minute.	Gallons per day.
		200		
Corley Sandstone ...	40	240	500	720,000
		360		
40-Feet Sandstone ...	40	400	1,500	2,160,000
		944		
Red Sandstone ...	20	964	2,650	3,816,000
		1520		
100-Feet Sandstone	50	1570		
		1780	Strata sunk through after cementation process had been applied.	

ANALYSES.

Keresley Water obtained from behind the tubbing of the shaft of the Warwickshire Coal Company at their Keresley Pit at depths of 255 and 480 ft.

Made by Messrs. Bostock Hill & Rigby, Birmingham, 2.3.1917 and 19.7.1917.

	Parts per 100,000	
	2.3.1917	19.7.1917
Free and saline ammonia	0	·004
Albuminoid ammonia...	·004	·006
Chlorine in chlorides	1·8	2·9
Nitrogen in nitrates and nitrites	trace	·08
Oxygen absorbed from permanganate at 80°F. in 4 hours	·032	·032
Total solids dried at 100°C.	42	51
Hardness : Temporary	13·5	19·1
Permanent	8·2	16·0
Total	21·7	35·1

Appearance.—No. 1 Bright, trace of brown suspended matter.

Analyses of saline water from the lower part of the Corley Beds at the bottom of the ' New Well,' Spon End.

Rep. Brit. Assoc. for 1890, p. 372.

1.—By A. Timmins, when first met with :—

	Grains
Total solids per gallon	561·05
Sulphur anhydride	239·91
Lime	37·80
Magnesium	12·09
Combined chlorine	66·10

2.—By Dr. Meymott Tidy, London Hospital Medical College, Whitechapel, London, March 16, 1888, after it had been flowing a short time :—

	Possible Composition.
Carbonates of lime and magnesia ...	27·0
Sulphates of lime and magnesia ...	90·5
Alkaline sulphates	300·0
Silica	1·0
Organic matter	0·0
Nitrate of magnesia	0·5
Chloride of sodium	134·9
	553·9
Actually found	557·8

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1. Allesley Road spring entering tank, Oct. 22, 1873.

2. Flowing spring from borehole, 200 ft. deep, Oct. 22, 1873. [Spon End Waterworks (Coventry Corporation).]

Sixth Report (1874), *Rivers Pollution Commission*, p. 116.

	Parts per 100,000	
	1.	2.
Temperature. Centigrade	10·8	10·8
Total solid impurity	32·66	26·88
Organic carbon	·067	·018
Organic nitrogen	·018	·004
Ammonia	0	0
Nitrogen in nitrates and nitrites ...	·338	·306
Total combined nitrogen	·356	·310
Previous sewage or animal contamination	3,060	2,740
Chlorine	1·70	1·60
Hardness: Temporary	15·7	11·1
Permanent	9·4	8·0
Total	25·1	19·1
Remarks	Clear and palatable	Clear and palatable

BRETTS STAMPING CO., LTD. BORING.

In Harnell Lane East. Made in 1914 and particulars communicated by Messrs. C. Isler & Co., Ltd.

	Thickness Ft.	Depth Ft.
Dug Well	76	76
Boring :—		
Sandstone	1	77
Red marl	5	82
Sandstone	1	83
Red marl	2	85
Sandstone	½	85½
Red marl	3½	89
Sandstone	12	101
Hard marl	5	106
Sandstone	½	106½
Hard marl	10	116½
Soft marl	½	117
Hard marl	9½	126½
Sandstone	14	140½
Hard marl	7½	148
Sandstone	3	151
Hard marl	6	157
Sandstone	6	163
Hard marl	7	170
Sandstone	2½	172½
Hard marl	12½	185
Harder marl	8	193
Sandstone	1	194
Very hard sandstone	1½	195½
Hard marl	1½	197
Sandstone	2	199
Hard sandstone	3	202
Sandstone and marl...	2	204
Hard marl		

Lined with 140 ft. of tubes, 6 in. in diameter, top 2 ft. down (bottom 60 ft. perforated). Water-level, 8 ft. ex surface.

COVENTRY TRAM DEPOT BORING.

No. 1 Borehole made in 1907 and communicated by Messrs. C. Isler & Co., Ltd. Height above O.D. 306 ft.

		Thickness Ft.	Depth Ft.
Dug well:—			
	Made ground	6	6
Boring:—			
	Marl	5	11
	Sand-rock	13	24
	Marl	3½	27½
	Conglomerate	7	34½
	Grey sand-rock	1½	36
	Marl with layers of rock ...	39½	75½
	Brown rock	20	95½
	Brown rock with layers of marl	57½	153
	Sand-rock	28	181
	Marl	11	192½
	Brown rock	9½	202
	Sand-rock	5	207
	Brown rock	12½	219½
	Sand-rock	6½	226
[Corley Beds	Brown rock with layers of marl	6½	232½
about Exhall	Sand-rock	4	236½
Conglomerate]	Marl	6	242½
	Marl with layers of rock ...	23	265½
	Sand-rock	3	268½
	Marl with layers of rock ...	8	276½
	Brown rock	5	281½
	Marl with layers of rock ...	23½	305
	Grey sand-rock	9	314
	Red sand-rock	16½	330½
	Conglomerate	8	338½
	Marl	5½	344
	Sand-rock	1½	345½
	Grey sand-rock	3½	349
	Brown rock	4	353
	Sand-rock	17	370
	Marl	2	372

Lined with 190 ft. of tubes, 10 in. in diameter
180 ft. ,, 8½ in. ,, (perforated).
10 ft ,, 8½ in. ,, (plain).

Supply, 8,000 gallons per hour.

MESSRS. S. COURTAULD & CO., LTD., FOLESHILL ROAD.

NO. 2 BOREHOLE.

Made and communicated by Messrs. C. Isler & Co., Ltd. Height above O.D., 310 ft.

		Thickness Ft.	Depth Ft.
[Lower part of Corley Beds and Keele Beds]	Made ground	4	4
	Sand, clay	6	10
	Red marl and stone	30	40
	Hard sandstone	12	52
	Soft sandstone	4	56
	Sandstone with beds of marl	27	83
	Hard sandstone	4	87
	Marl with beds of sandstone	31	118
	Hard marl	3	121
	Sandstone with beds of marl	43	164
	Marl	15	179
	Sandstone with beds of marl	47	226
	Marl	17	243
	Sandstone	18	261
	Marl	62	323
	Hard marl and sandstone	15	338
	Marl	102	440
	Sandstone	34	474
	Marl	28	502
	Sandstone	21	523
	Marl and sandstone	33	556
	Sandstone	16	572
	Marl	15	587
	Sandstone and marl	32	619
	Sandstone	18	637
	Marl	2	639
	Sandstone with beds of marl	25	664
	Sandstone	15	679
	Marl	12	691
	Sandstone	16	707
	Marl	4	711
	Sandstone	3	714
	Marl	3	717
	Sandstone	5	722
	Marl	2	724
	Sandstone with marl	9	733
	Sandstone	15	748
	Marl	2	750
	Sandstone	18	768
	Marl	32	800
	Grey sandstone	11	811
	Marl	74	885
	Sandstone, yellow	9	894
	Red marl	12	906
	Conglomerate	3	909
	Marl	12	921
	Sandstone	10	931
	Marl	4	935
	Sandstone	5	940
	Marl	3	943
	Sandstone	4	947
	Marl	108	1055

Lined with 435 ft. of tubes, 15½ in. in diameter, top 2½ft.
300 ft. ,, 13½ in. ,, ,, 323 down.
295 ft. ,, 11½ in ,, ,, 585 ,,
153 ft. ,, 10 in. ,, ,, 852 ,,
Rest-level, 46 ft. ex surface.

MESSRS. S. COURTAULD & CO., LTD., FOLESHILL ROAD.

No. 1. BOREHOLE.

Made in 1908 and communicated by Messrs. C. Isler & Co., Ltd. Height above O.D., 300 ft.

		Thickness Ft.	Depth Ft.
Dug well		85	85
Boring :—			
	Sandstone	12	97
	Brown marl	2½	99½
	Red marl	61	160½
	Brown marl	4½	165
	Red marl	60	225
	Red sandstone	2	227
	Red marl	13	240
	Red sandstone	1½	241½
	Red marl	25½	267
	Red sandstone	2	269
	Marl with thin beds of sandstone	71	340
	Sandstone	1	341
	Red blue marl	9	350
	Sandstone	1	351
[Lower part of Corley Beds between the Corley and Exhall Conglomerates]	Marl with beds of sandstone	34	385
	Sandstone	14	399
	Marl with beds of sandstone	81	480
	Sandstone	28	508
	Red marl	5	513
	Sandstone	7	520
	Red marl	10	530
	Sandstone	7	537
	Mottled clay	4	541
	Sandstone	7	548
	Red marl	3	551
	Hard sandstone and rock	11	562
	Red sandstone	78	640
	Hard marl	23	663
	Hard sandstone	4	667
	Hard marl	8	675
	Sandstone	14	689
	Sandstone and marl	13	702

Tubes :—

380 ft. × 13½ in.—3 ft. down.
90 ft. × 11½ in.—perforated.
140 ft. × 11½ in.—plain.
10 ft. × 11½ in.—perforated.
15 ft. × 11½ in.—plain.
380 ft. × 13½ in.—3 ft. down.
255 ft. × 11½ in.—369 ft. down.

Rest-level 14 ft. ex surface. Yield, 19,000 gallons per hour.

No. 3 BOREHOLE.

Height above O.D., 300 ft.

Lower part of Corley Beds	300 ft.

No. 4 Borehole.

Height above O.D., 300 ft.

Lower part of Corley Beds	576 ft.	

Messrs. Howes, Dye Works, Meadow Street, Coventry.

Made in 1866. R. C. Sinclair in *Rep. Brit. Assoc.* for 1875, p. 136. Height above O.D., 260 ft.

Well (17 ft.) and boring (120 ft.) 7 in. diameter :—

		Thickness Ft.	Depth Ft.
[Corley Conglomerate]	Drift	11	11
	Red sandstone	1	12
	Conglomerate	6	18
	Permian sandstone, very variable in colour and hardness...	119	137

Always flowing over top of well, pump cannot lower it.

Yield, 500,000 gallons per 24 hours. Quality of Water.—Clear and light ; no incrustation left on boilers ; water considered soft.

Humber Co.'s Borehole, Folly Lane.

Made and communicated by Messrs. C. Isler & Co., Ltd. Height above O.D, 270 ft.

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Lower part of Corley Beds and upper part of Keele Beds]	Red marl	10	0	10	0
	Hard sand-rock	24	0	34	0
	Red marl	2	0	36	0
	Hard sand-rock	2	6	38	6
	Red marl	7	6	46	0
	Rock	2	6	48	6
	Red marl	6	0	54	6
	Rock	2	6	57	0
	Red marl	6	0	63	0
	Conglomerate rock	12	0	75	0
	Sandstone	22	0	97	0
	Red marl	4	0	101	0
	Rock	5	0	106	0
	Shale	5	0	111	0
	Red sandstone	13	0	124	0
	Red shale	4	0	128	0
	Red sandstone	37	0	165	0
	Marl with layers of sandstone ...	40	0	205	0
	Red sandstone	13	0	218	0
	Red marl	6	0	224	0
	Red sandstone	4	0	228	0
	Red marl	13	0	241	0
	Red sandstone	16	0	257	0
	Red marl	12	0	269	0
	Sandstone	1	6	270	6
	Red marl	18	6	289	0
	Hard rock	10	0	299	0
	Shale	4	6	303	6

		Thickness Ft.	Thickness In.	Depth Ft.	Depth In.
[Lower part of Corley Beds and upper part of Keele Beds]	Red marl	5	6	309	0
	Shale	5	0	314	0
	Red marl	15	0	329	0
	Sandstone	11	0	340	0
	Red marl	15	0	355	0
	Shale	5	0	360	0
	Red marl	2	0	362	0
	Shale	5	6	367	6
	Sandstone	1	0	368	6
	Shale	3	6	372	0
	Sandstone	5	6	377	6
	Red marl	5	0	382	6
	Shale	15	0	397	6
	Sandstone	7	0	404	6
	Red marl	43	0	447	6
	Shale rock	15	6	463	0
	Sandstone	45	0	508	0
	Shale	2	0	510	0

Lined with 290 ft. of tubes, 10 in. in diameter, top 5 ft. down.
105 ft. ,, 8½ in. ,, ,, 269 ,,
155 ft. ,, 7¼ in. ,, ,, 345 ,,

Water-level, 17 ft. ex surface. Yield.—Tested to 5,800 gallons per hour.

MIDLAND BREWERY (MESSRS. PHILLIPS & MARRIOTT, LTD.), MUCH PARK STREET.

Made and communicated by Messrs. C. Isler & Co., Ltd. Height above O.D., 280 ft.

		Thickness Ft.	Depth Ft.
	Dug Well	53	53
	Boring :—		
[Corley Conglomerate.]	Sand-rock	17½	70½
	Sandy marl	2½	73
	Conglomerate and clay... ...	10	83
	Sand-rock with thin layers of clay	22	105
	Sand-rock	9	114
	Red clay	11	125
	Clay with thin layers of rock	6	131
	Sand-rock	40	171
	Clay	11	182
	Sand-rock	20	202
	Clay, mostly	12	214
	Sand-rock	7½	221½

Lined with 20 ft. of tubes, 10 in. in diameter, top 39 ft. down.
168 ft. ,, 7¼ in. ,, ,, 36½ ft. ,,

Supply.—Tested to 5,850 gallons per hour.

STANDARD MOTOR CO., LTD.

At Canley Gates. Made and communicated by Messrs. C. Isler & Co., Ltd.

		Thickness Ft.	Depth Ft.
[Corley Group]	Marl	16	16
	Sandstone	3	19
	Marl	38	57
	Fine-grained sandstone ...	40	97
	Sandstone and marl	47	144
	Sandstone	13	157
	Sandstone and marl	16	173
	Conglomerate	1½	174½
	Marl	21½	196
	Sandstone	1	197
	Marl	7	204
	Marl and sandstone	20	224
	Sandstone	8½	232½
	Marl	16½	249
	Sandstone	13	262
	Marl	15	277
	Sandstone	1½	278½
	Marl	1½	280

Lined with 14 ft. 7 in. of tubes, 11½ in. in diameter, top 4 ft. down.
172 ft. 6 in. ,, 8½ in. ,, ,, 1½ft. ,,

Water-level, 8 ft. ex surface.

Certain Wells and Boreholes. Ex ' Coventry Memoir ', pp. 126-128.

Name.	Height above O.D. (in feet)	Depth (in feet)	Water-level (rest)	Yield (gals. per 24 hours)	Geological Horizon.	Remarks.
Coventry Gas Works (Well), A.	297	94	—	—	Lower part of Corley Beds	——
Coventry Gas Works (Well), B.	297	22¼	6¼	100,000	Do.	Failed in 1912 and 1913 owing to sinking of Coventry Colliery.
Coventry Gas Works (Well), C.	309	325	24	384,000	Do.	——
Leigh Mills, Gas Street (W. and B.H.)	270	200	—	—	Corley Conglomerate	Well to 72 ft., 6 ft. diam. B.H. 129 ft. to 200 ft., 6 in. diam.
Ordnance Works. No. 1 B.H.	310	352	42	240,000	Lower part of Corley Beds about Exhall Conglomerate.	8½ to 7¼ in. diam.
Ordnance Works. No. 2 B.H.	310	624	42	360,000	Do. and upper part of Keele Beds.	11 to 7 in. diam.

VI.—BIBLIOGRAPHY

Maps.

Quarter-Inch Maps.

Revised Series and printed in Colours.

Sheet 11. Small northern portion of the county.
„ 15. Main portion of the county.

One-Inch Maps. Old Series.

44. Ilmington, Stretton-on-the-Fosse, Honington, Barcheston, Great Wolford, Barton-on-the-Heath, Little Compton.
45 N.W. Long Compton, Cherrington, Brailes, Compton Wynyates, etc.
53 S.E. Small area around Flecknoe.
53 S.W. Bishops Tachbrook, Southam, Fenny Compton, Kineton.
53 N.E. Hillmorton (near Rugby), Clifton, Churchover.
53 N.W. Rugby, Coventry, Leamington Spa, Granborough.
54 S.E. Stratford-on-Avon, Alcester, etc.
54 S.W. Weethley.
54 N.E. Knowle, Berkswell, Studley, Henley-in-Arden, Claverdon, Hatton.
54 N.W. Ipsley.
63 S.E. Very small portion in extreme S.E. corner.
63 S.W. Atherstone, Nuneaton, Bulkington, Monks Kirby.
63 N.W. Newton Regis, Austrey, Grendon.
62 N.E. Sutton Coldfield (part), Wilncote, Polesworth, Seckington.
62 S.E. Sutton Coldfield, Birmingham, Kingsbury, Meriden.
62 S.W. S.W. Harborne.

One-Inch Maps. New Series.

154. Tamworth, Sutton Coldfield (part), Middleton, Kingsbury (part).
155. Seckington, Shuttington, Warton, Polesworth, Baddesley Ensor, Atherstone.
168. Sutton Coldfield (part), Birmingham, Kingsbury (part), Berkswell.
169. Baxterley, Tile Hill, Nuneaton, Bedworth, Coventry, Bulkington, Brinklow.

Six-Inch Maps.

Of the six-inch maps contained in the New Series one-inch sheets, many that cover the coalfield districts have been published, hand-coloured. Prices of these may be obtained on application to the Director General, Ordnance Survey, Southampton, and uncoloured copies with engraved geological lines may also be obtained from that officer, price 2/3 each. Coloured copies of the unpublished six-inch maps can be supplied at the cost of drawing and colouring on application to the Director, Geological Survey, 28 Jermyn Street, London, S.W.1., who will furnish estimates of cost.

Horizontal Sections.

Scale: 6 inches = 1 mile.

(Those marked thus [1] have brief explanations).

48[1]. From Lazy Hill to Glascote, the north end of the Warwickshire Coalfield, Grendon . . .
49[1]. No. 1. From Barr Beacon, across the Warwickshire Coalfield . . . 2. From Bodymoor Heath, near Kingsbury, across the Warwickshire Coalfield, through Cliff, Shuttington . . .
50[1]. From near Cleobury Mortimer, Worcestershire, to the Ashby Canal, near Nuneaton, across the Warwickshire Coalfield . . . Meriden, Corley . . .

51[1]. No. 1. Across the south part of the Warwickshire Coalfield, near Bedworth. 2. Across the Coalfield of Warwickshire, through Arley Wood, to between Nuneaton and Atherstone.

82. From Handborough in Oxfordshire to Milverton near Royal Leamington Spa.

83. From east of Kenilworth to the River Anker, near Tamworth.

140[1]. Through Warwickshire from Rugby to near Wibtoft (near Hinckley)

VERTICAL SECTIONS.

Scale: 40 ft. to an inch.

Sheet 21. Warwickshire Coalfield. 1. Glascote Colliery. 2. Wilnecote Colliery. 3. Kettlebrook Colliery. 4. Polesworth Colliery. 5. Wyken Colliery, near Coventry; Inge's Old Works. 6. Baddesley Colliery (Speedwell Pit). 7. Pit sunk at Merevale to the Bench Coal. 8. Boring at Merevale beneath the Bench Coal. 9. Stratford Colliery, Baxterley. 10. Section of Coals in the Hawkesbury Colliery. 18. Haunchwood Colliery, Nuneaton. 12. Bedworth Colliery. 13. Hawkesbury Colliery, near Bedworth. 14. Exhall Colliery, near Coventry; with an explanation of the local names of strata.

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